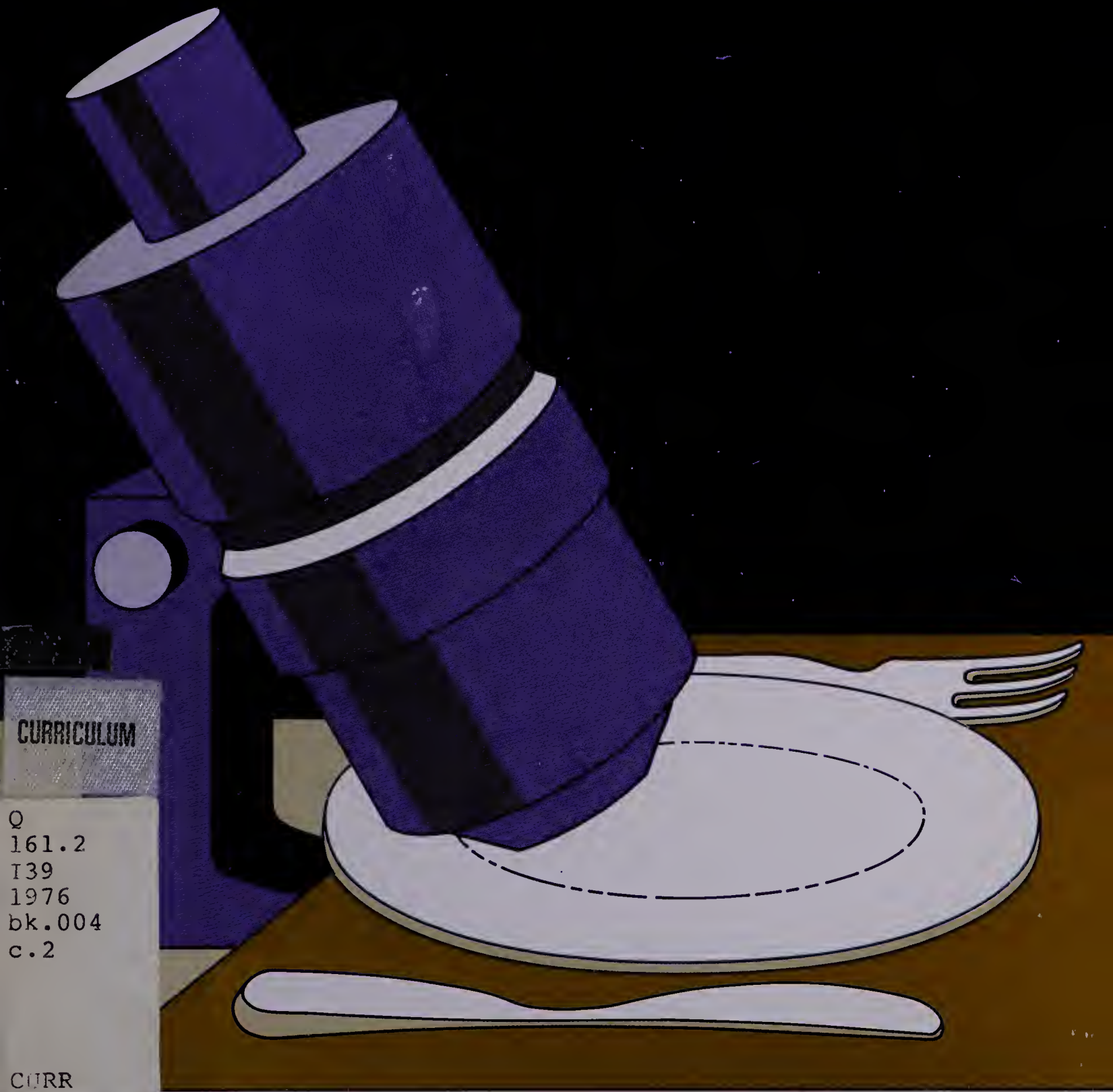
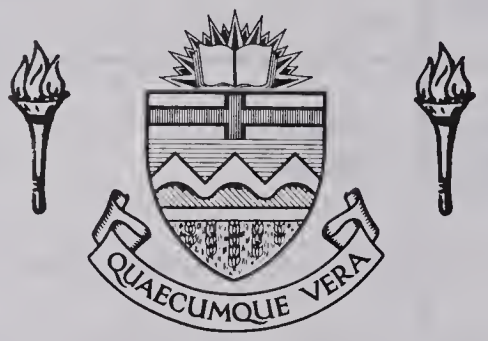
ISIS

INDIVIDUALIZED SCIENCE INSTRUCTIONAL SYSTEM

FOOD AND MICROORGANISMS





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Ginn and Company

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FOREWORD

Evidence has been mounting that something is missing from secondary science teaching. More and more, students are rejecting science courses and turning to subjects that they consider to be more practical or significant. Numerous high school science teachers have concluded that what they are now teaching is appropriate for only a limited number of their students.

As their concern has mounted, many science teachers have tried to find instructional materials that encompass more appropriate content and that allow them to work individually with students who have different needs and talents. For the most part, this search has been frustrating because presently such materials are difficult, if not impossible, to find.

The Individualized Science Instructional System (ISIS) project was organized to produce an alternative for those teachers who are dissatisfied with current secondary science textbooks. Consequently, the content of the ISIS materials is unconventional as is the individualized teaching method that is built into them. In contrast with many current science texts which aim to "cover science," ISIS has tried to be selective and to limit our coverage to the topics that we judge will be most useful to today's students.

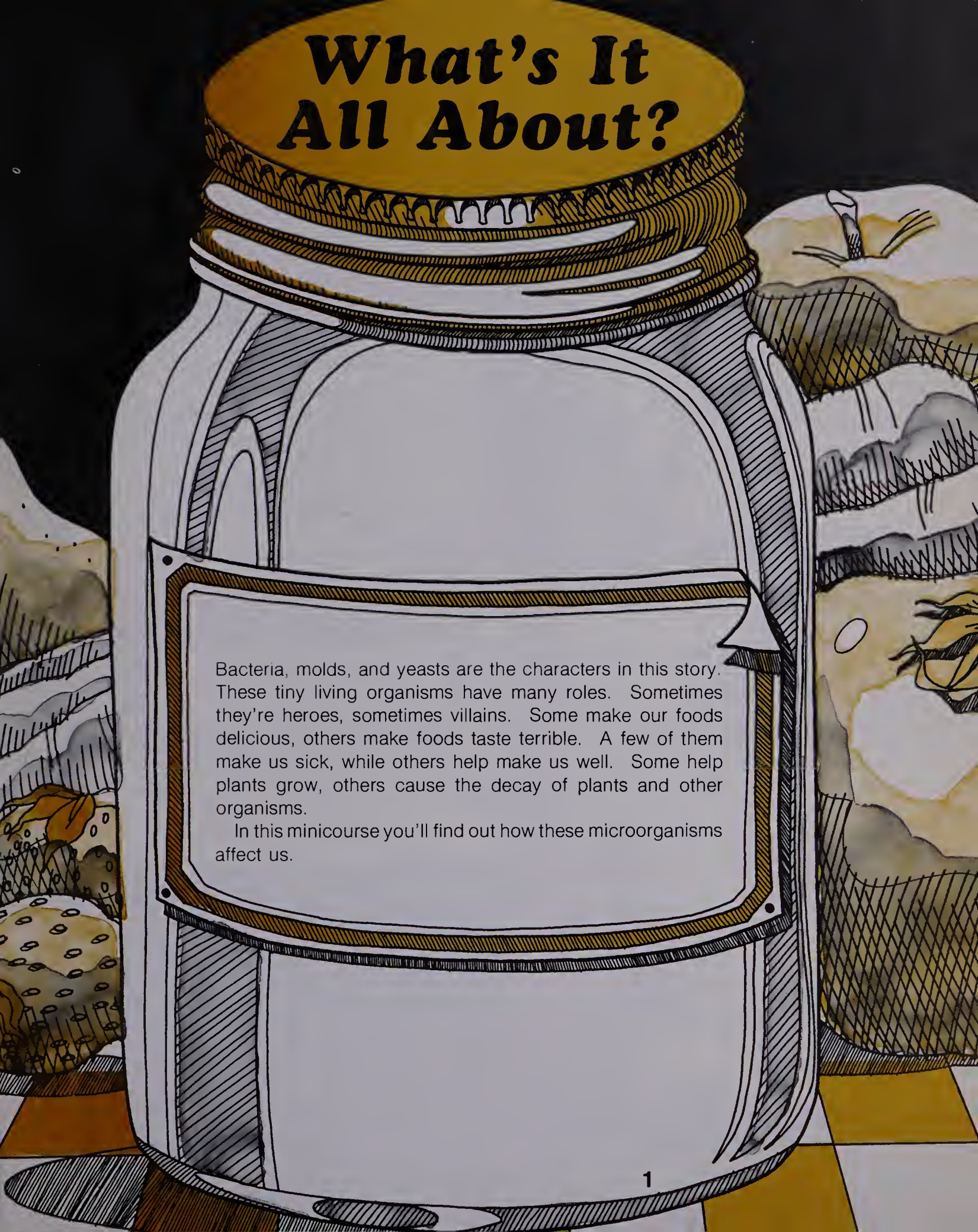
Obviously the needs and problems of individual schools and students vary widely. To accommodate the differences, ISIS decided against producing tightly structured, pre-sequenced textbooks. Instead, we are generating short, self-contained modules that cover a wide range of topics. The modules can be clustered into many types of courses, and we hope that teachers and administrators will utilize this flexibility to tailor-make curricula that are responsive to local needs and conditions.

ISIS is a cooperative effort involving many individuals and agencies. More than 65 scientists and educators have helped to generate the materials, and hundreds of teachers and thousands of students have been involved in the project's nationwide testing program. All of the ISIS endeavors have been supported by generous grants from the National Science Foundation. We hope that ISIS users will conclude that these large investments of time, money, and effort have been worthwhile.

Ernest Burkman
ISIS Project
Tallahassee, Florida

CONTENTS

What's It All About?



Bacteria, molds, and yeasts are the characters in this story. These tiny living organisms have many roles. Sometimes they're heroes, sometimes villains. Some make our foods delicious, others make foods taste terrible. A few of them make us sick, while others help make us well. Some help plants grow, others cause the decay of plants and other organisms.

In this minicourse you'll find out how these microorganisms affect us.

core

Activity 1 Planning

If you plan to do Activity 3 or 9, do Activity 2 first. The other activities can be done in any order.

Activity 2 Page 5

You will grow microorganisms, tiny living creatures, on a variety of foods. After 3 or 4 days, you can observe the growth of these organisms in Activities 3 and 9.

Activity 3 Page 8

Objective 1: Name three groups of microorganisms that can be helpful or harmful to people.

Sample Question: What three groups of microorganisms cause decay and spoil food?

Objective 2: Describe what decomposer organisms do.

Sample Question: Decomposer organisms are helpful because they

a. return simple materials to the soil.
b. can manufacture their own food, like plants do.
c. break up soil into smaller pieces.

Objective 3: Tell whether a microorganism is a mold, yeast, or bacterium without using a microscope.

Sample Question: What microorganism is growing on the food (bread) below?

Activity 4 Page 13

Objective 4: Tell how bacteria recycle nitrogen gas and nitrogen compounds.

Sample Question: Match each microorganism given in List A with its function in List B.

List A

a. decomposing bacteria
b. nitrogen-fixing bacteria
c. nitrifying bacteria

List B

1. change nitrogen, from the air, into compounds plants can use
2. break down dead plants and animals
3. change nitrogen, in the soil, into compounds plants can use
4. release nitrogen gas into the air

Activity 5 Page 18

Objective 5: Tell how drying food helps keep it from spoiling.

Sample Question: Dried foods rarely spoil because

a. the dried outer crust of the food keeps food spoilers away.
b. drying produces an acid that kills food spoilers.
c. dried foods don't contain enough water for food spoilers to grow.

Objective 6: Name ways of drying food to preserve it.

Sample Question: How can you dry a food to preserve it?

a. Place it outside in the shade.
b. Pack it in salt or sugar.
c. Remove all salt or sugar in it.

Answers

1. bacteria, molds, yeasts 2. a 3. mold 4. a2, b1, c3 5. c 6. b 7. a 8. a

Activity 6 Page 23

Objective 7: Describe how the acidity of a food affects its preservation.

Sample Question: Which food is least likely to spoil from bacterial growth?

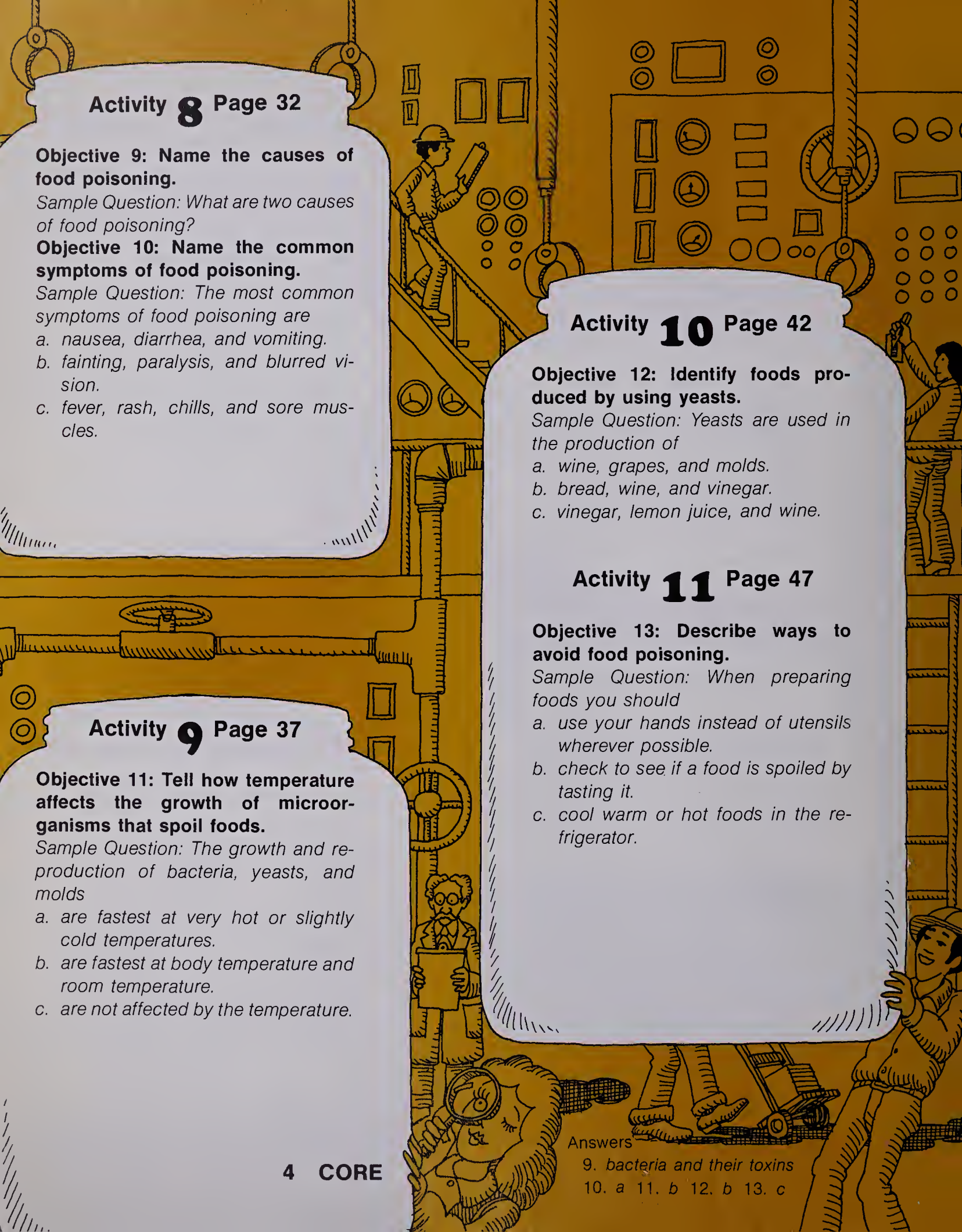
a. food high in acid
b. food medium in acid
c. food low in acid

Activity 7 Page 28

Objective 8: Identify arguments for and against the use of food additives.

Sample Question: Generally additives are put into foods because

a. their good effects outweigh their possible bad ones.
b. they have no possible bad effects.
c. their possible bad effects outweigh their good effects.



Activity 8 Page 32

Objective 9: Name the causes of food poisoning.

Sample Question: What are two causes of food poisoning?

Objective 10: Name the common symptoms of food poisoning.

Sample Question: The most common symptoms of food poisoning are

a. nausea, diarrhea, and vomiting.
b. fainting, paralysis, and blurred vision.
c. fever, rash, chills, and sore muscles.

Activity 9 Page 37

Objective 11: Tell how temperature affects the growth of microorganisms that spoil foods.

Sample Question: The growth and reproduction of bacteria, yeasts, and molds

a. are fastest at very hot or slightly cold temperatures.
b. are fastest at body temperature and room temperature.
c. are not affected by the temperature.

Activity 10 Page 42

Objective 12: Identify foods produced by using yeasts.

Sample Question: Yeasts are used in the production of

a. wine, grapes, and molds.
b. bread, wine, and vinegar.
c. vinegar, lemon juice, and wine.

Activity 11 Page 47

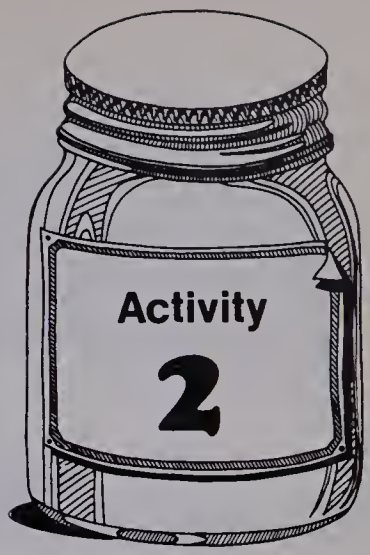
Objective 13: Describe ways to avoid food poisoning.

Sample Question: When preparing foods you should

a. use your hands instead of utensils wherever possible.
b. check to see if a food is spoiled by tasting it.
c. cool warm or hot foods in the refrigerator.

Answers
9. *bacteria and their toxins*
10. *a* 11. *b* 12. *b* 13. *c*

Getting Started



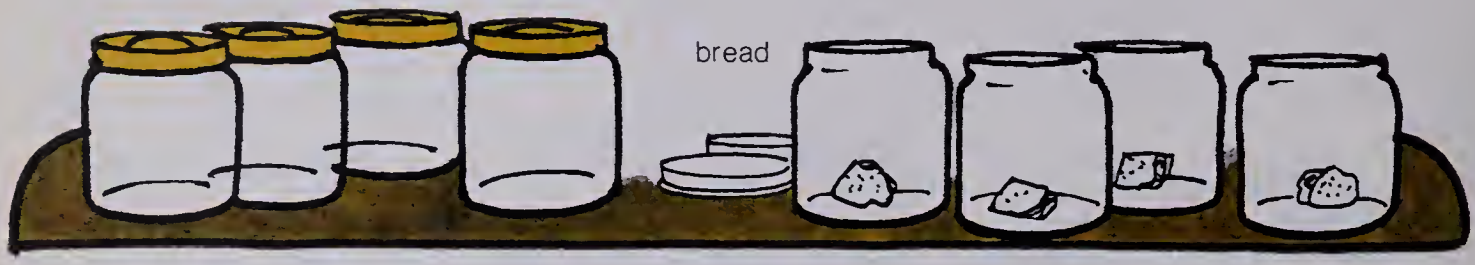
At least four days before you do Activities 3 and 9, you will need to grow some microorganisms. These are tiny living things that are found almost everywhere around you. However, they can be seen only with a microscope unless thousands are growing in one place.

You will grow your microorganisms on a variety of foods. Your teacher may supply some foods. You might bring most of what you need from the school cafeteria or from home. Actually, the whole activity can be done at home. You will need these items:

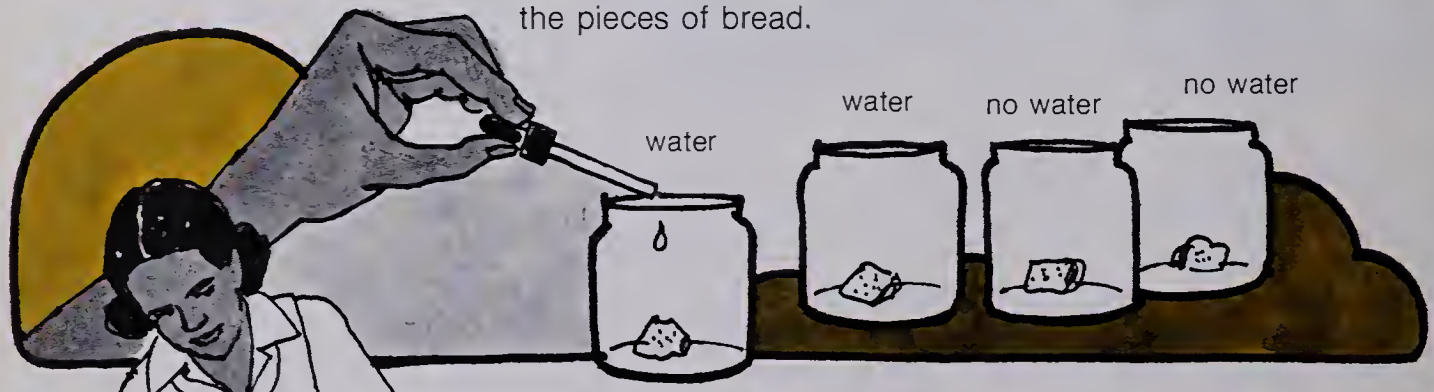
8 containers with lids, such as baby-food jars or petri dishes
medicine dropper
grease pencil
4 small pieces of bread
1–2 tablespoons of milk
some hamburger or a piece of bologna or other sandwich meat, about 1 cm x 1 cm
small piece of raw apple, peach, orange, or other tart fruit
1–2 cooked peas, string beans, lima beans, or similar cooked green vegetables

Before you begin, read through all the directions. Notice that you will prepare 2 sets of containers.

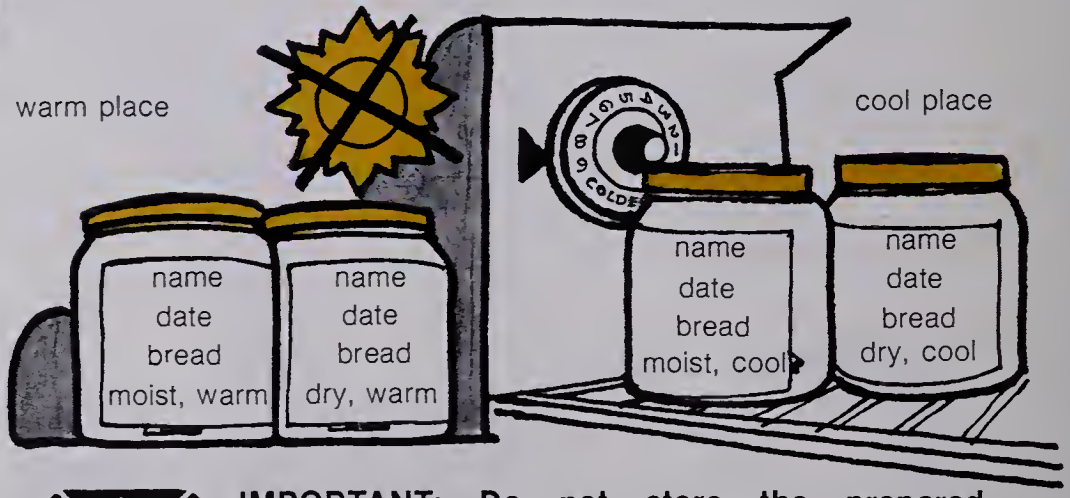
A. Make sure that the 8 containers are clean and dry. Put a piece of bread into each of 4 containers. Put the other 4 containers aside until Step D.



B. Use a medicine dropper to put 3 to 5 drops of water on two of the pieces of bread.



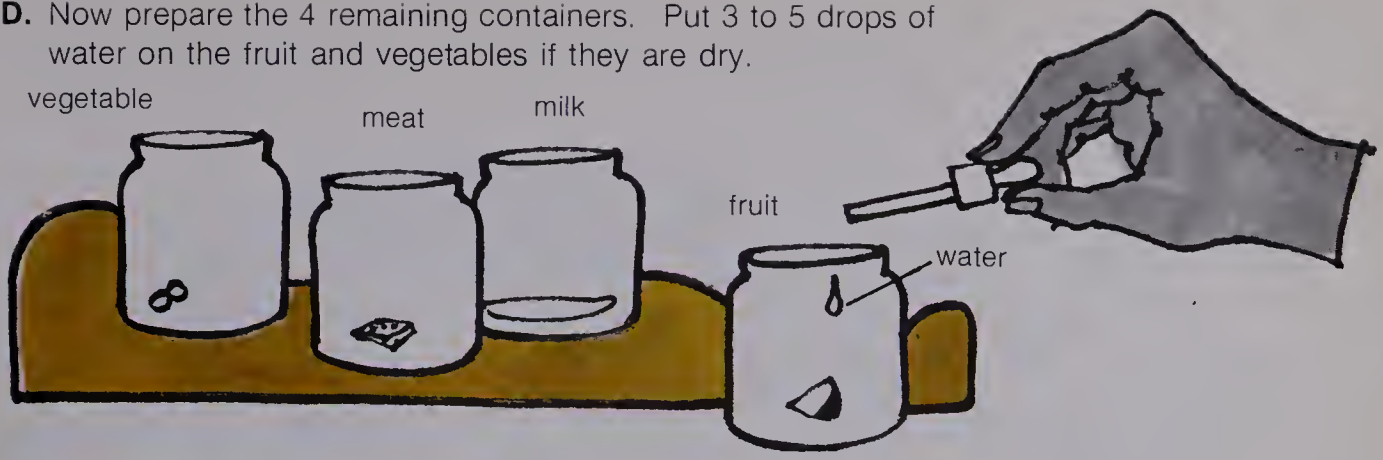
C. Cover each of the 4 containers with a lid or plastic wrap. Label the containers and store them as shown.



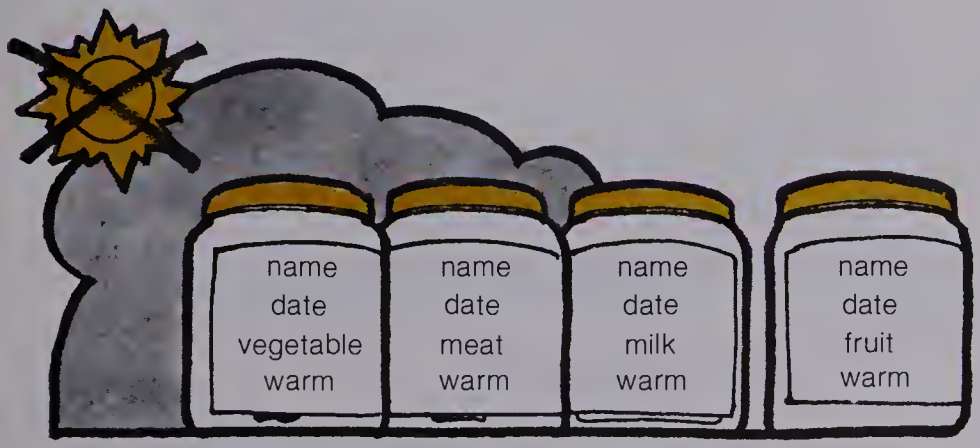
IMPORTANT: Do not store the prepared containers in direct sunlight. All the containers should be placed where they will not be disturbed.

The containers and what grows inside will be used in Activities 3 and 9. Remember to wait at least 4 days before doing those activities.

D. Now prepare the 4 remaining containers. Put 3 to 5 drops of water on the fruit and vegetables if they are dry.



E. Cover each container with a lid or plastic wrap. Label and store each container as shown.



The containers and what grows inside will be used in Activity 3. Remember to wait at least 4 days before doing that activity.

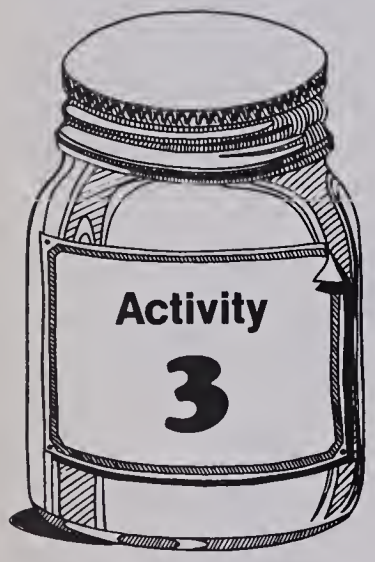
Most, perhaps all, of the microorganisms that will grow are harmless to you. But there is a small chance that one or more of them could cause an allergic reaction, an infection, or even a serious illness. There is no danger, however, if you follow these safety rules.

While you are doing other activities, check the containers each day to see what changes are taking place. Record your observations in a table like Figure 2-1.

OBSERVING THE GROWTH OF MICROORGANISMS

DAY	BREAD	MILK	MEAT	FRUIT	VEGETABLES
1					
2					
3					
4					

Figure 2-1



Microorganisms Everywhere

Microorganisms are everywhere—bacteria, yeasts, molds. Often they are so small that they are almost invisible unless you use a microscope. This explains why they are called *microorganisms,* a very big word for such tiny living things. Microorganisms, whether you can see them or not, are on your hands, inside your body, in the air, water, soil. They are almost anywhere you can think of. In this activity, you'll look at the microorganisms that you started in Activity 2.

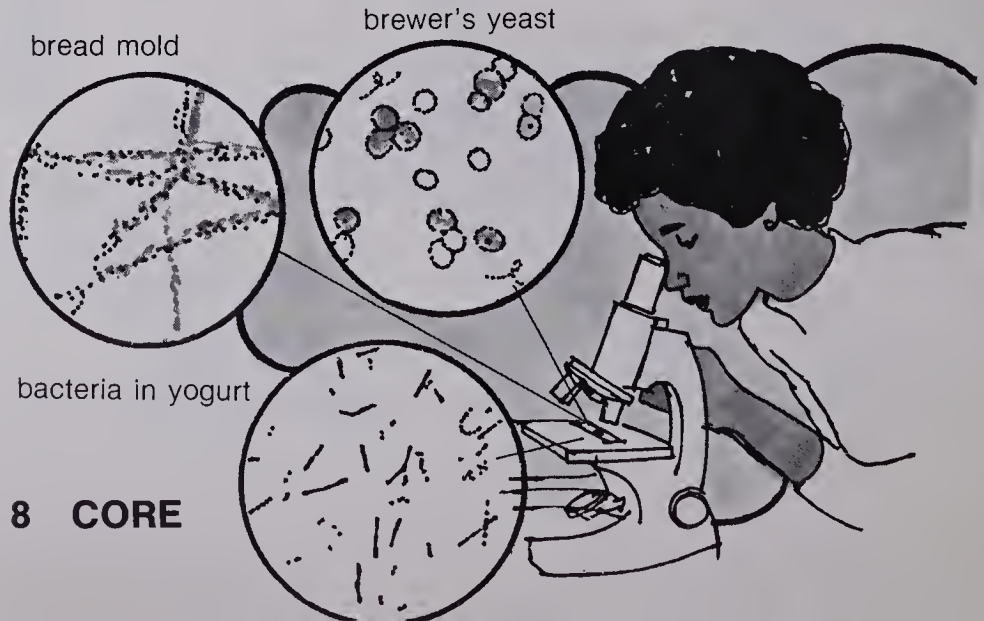


Figure 3-1 shows some of the effects and uses of microorganisms: bacteria and fungi (FUN-ji). Fungi are organisms such as yeasts, molds, smuts, rusts, mildews, and mushrooms.

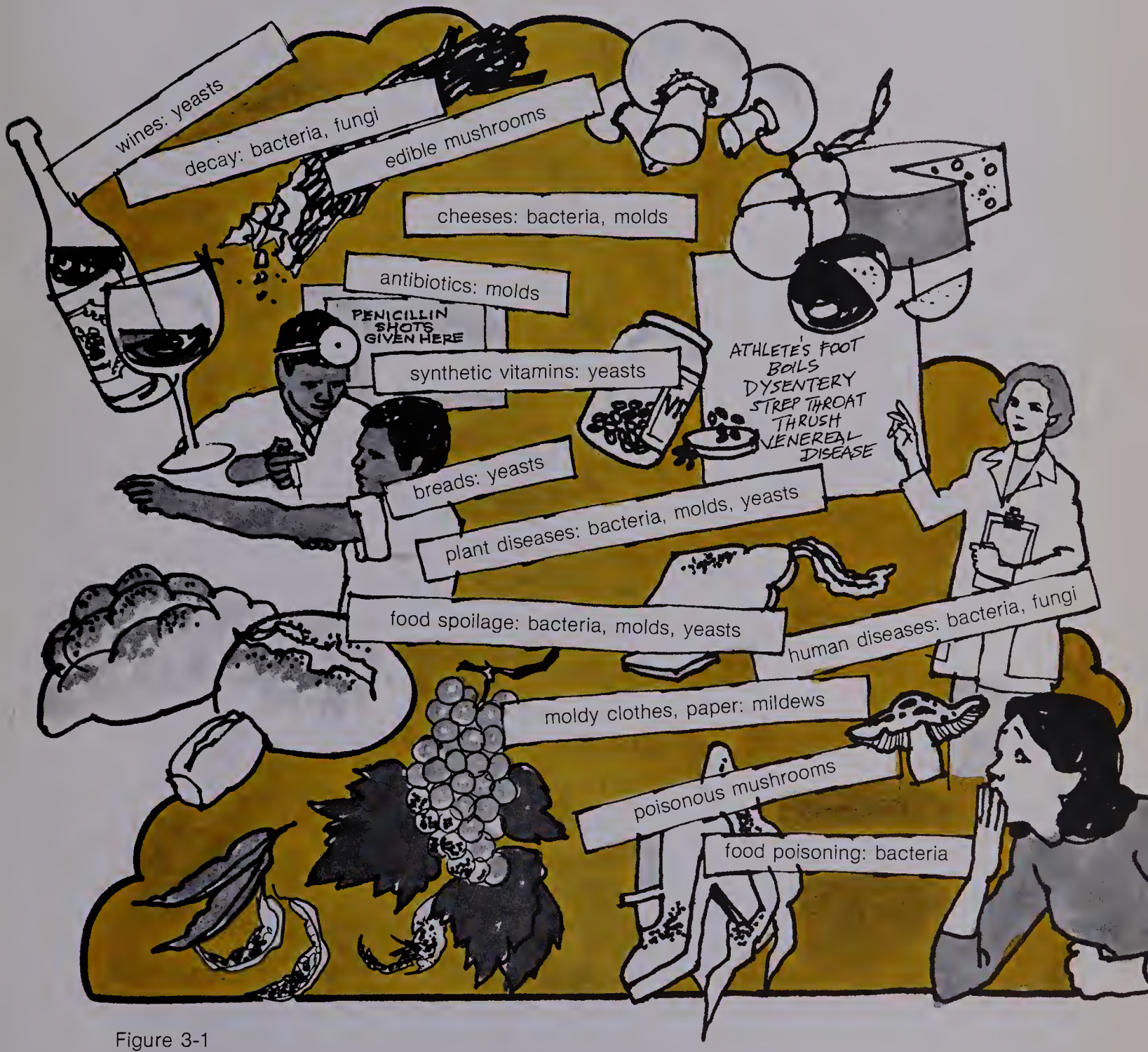


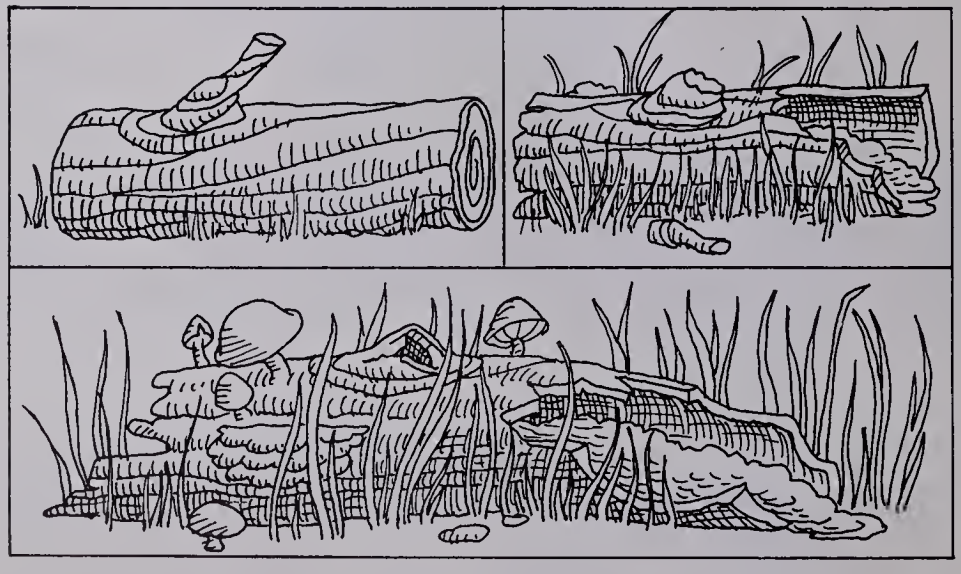
Figure 3-1

★ **3-1. How are microorganisms helpful to people? How do they cause harm or cause trouble?** (Use Figure 3-1 to help you answer.)

You probably know about microorganisms that cause decay and spoilage. Decay and spoilage are similar. But from the human point of view, one is good and one is bad. You don't want your food to spoil before you eat it. Yet you want the leftovers to decay and not last forever.

Some fungi and bacteria use your food to get food for their own growth. Like people, these microorganisms must use other plants and animals for their food. When they do this, they cause plants and animals to decay. Causing decay is one of the good effects of microorganisms. Just imagine, for example, what would happen if tree leaves never decayed.

Some kinds of bacteria cause decay; so do fungi. The microorganisms that cause decay are called *decomposers*. They decompose, or break down, complex dead materials into simpler materials. The simple materials return to the soil and are taken up by growing plants. The plants in turn are eaten by animals. The animals and other plants die. Again the decomposers go to work. They break down the dead materials, and the simpler materials return to the soil. The cycle goes around and around.



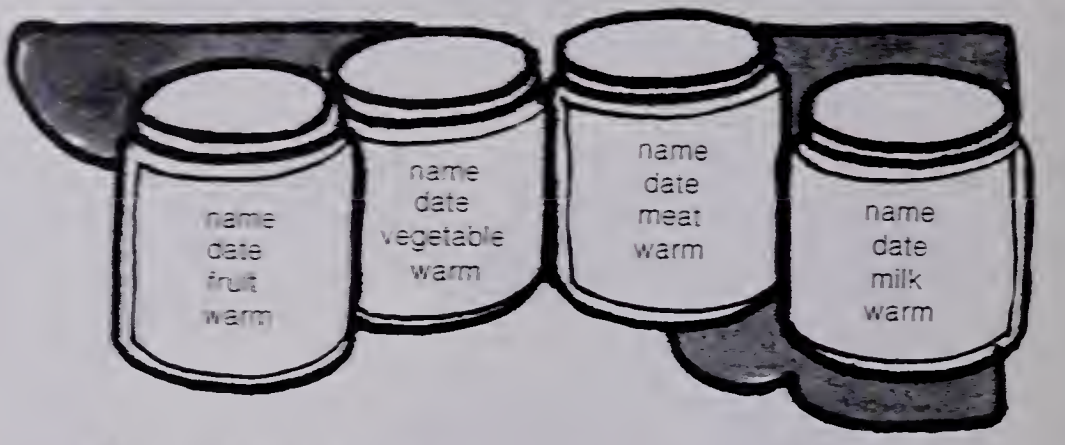
★ 3-2. Where do decomposers—bacteria and fungi—get the food they need for growth?

★ 3-3. Why do some people bury food scraps in the ground where they plan to have a garden?

✔ 3-4. Where would you look to find decomposers?

Only a few places are almost entirely free of decomposers—hospital operating rooms, quarantine rooms for returning astronauts, the frozen Arctic and Antarctic, and canned foods.

Look at the containers of food that you set up in Activity 2. If there is no spoilage, wait a day or two. When the food has begun to spoil in several containers, answer Questions 3-5, 3-6, and 3-7.



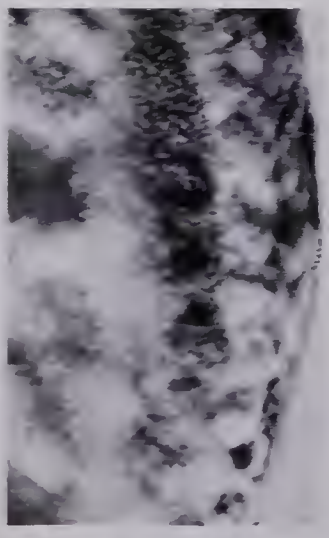
✔ 3-5. How many different kinds of microorganisms do you think you have in your containers?

✔ 3-6. Would you call these food spoilers harmful or helpful? Explain your answer.

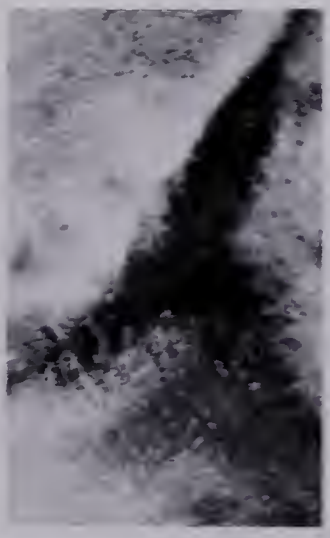
A variety of microorganisms are growing on the foods pictured in Figure 3-2. Growths of molds generally look fuzzy and thread-like. Compared to molds, bacteria grow where it is wetter and less acidic; bacterial growths usually look more waxy and jellylike.

Figure 3-2

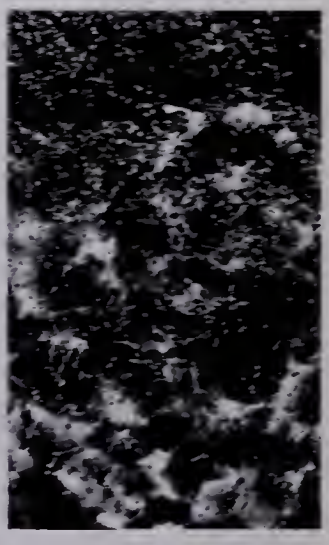
growth on meat



growth on fruit



growth on vegetable



growth on bread

Growths of yeasts look very much like those of bacteria; but the odor of yeasts is easy to identify. It's similar to the smell of baking bread. And when yeasts grow in a liquid, they make it look cloudy.

✔ 3-7. Look at your jars. Which kind of organisms may be growing

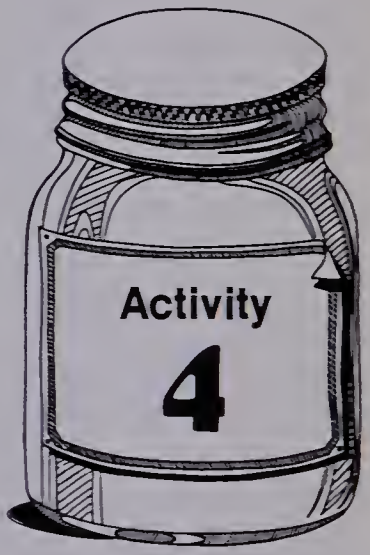
a. on the meat?
b. on the fruit?
c. in the milk?
d. on the vegetable?
e. on the bread?

★ **3-8. What do growing molds look like?**

★ **3-9. How do bacterial growths look?**

★ **3-10. How could you detect growing yeasts?**

★ **3-11. Name the groups of microorganisms that decay dead material.**

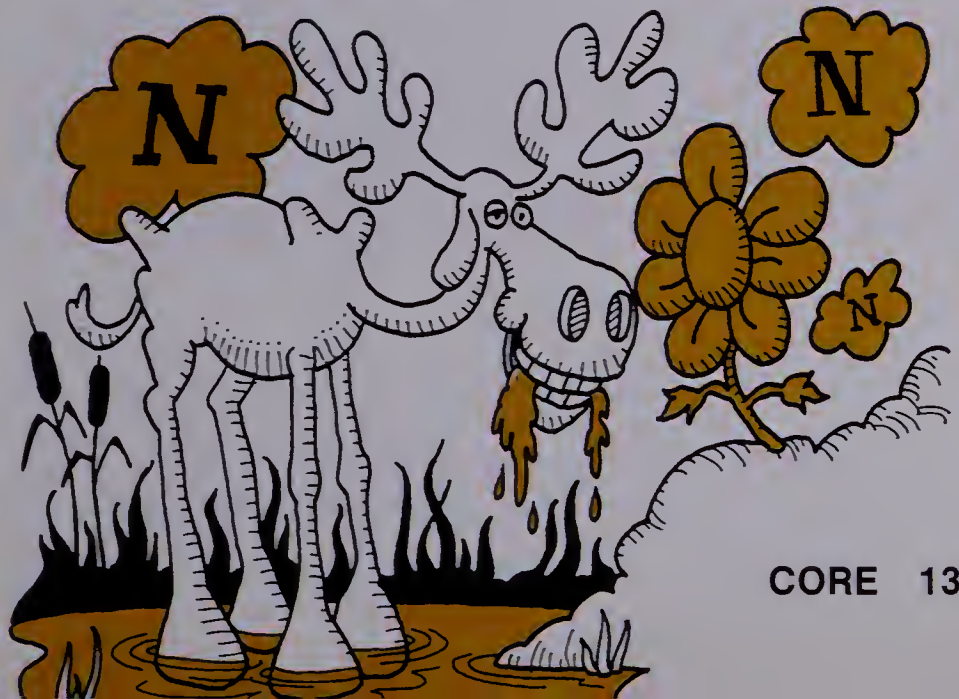


A Good Breed of Bacteria

All living things are made up of proteins. Nitrogen is part of all proteins. Thus all living things need nitrogen.

Nitrogen is one of the gases in the air. Only a few microorganisms can get the nitrogen they need directly from the air.

Animals get nitrogen from the things they eat—from animal and plant proteins. Plants get nitrogen from the soil.



So nitrogen passes, or cycles, through the environment—through plants, animals, the soil, and the air. Figure 4-1 traces the pathway that nitrogen takes.

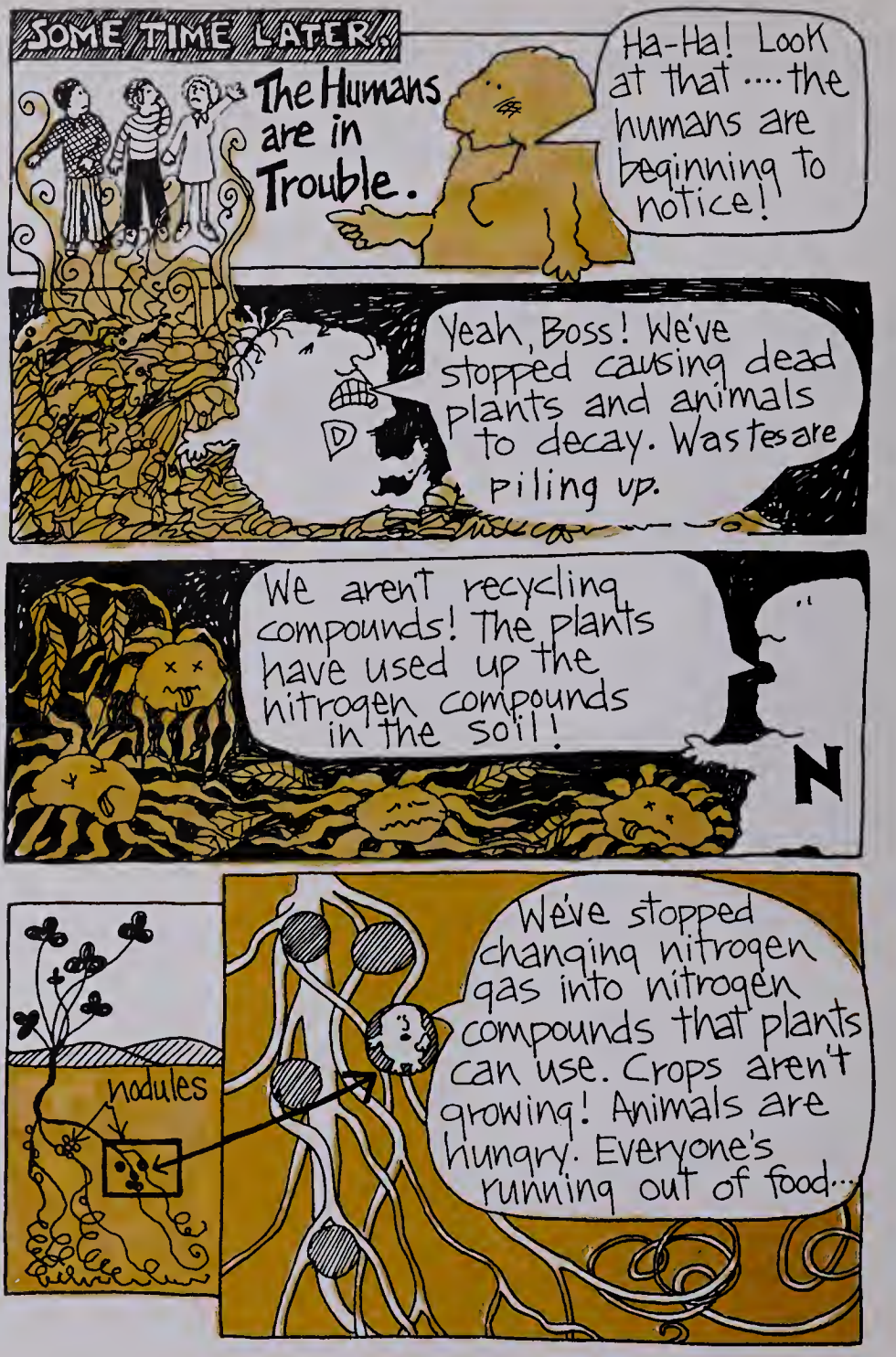
Figure 4-1

Several kinds of bacteria help to recycle nitrogen through the environment. The story that follows is about these microorganisms: the nitrogen-fixing bacteria, the decomposing bacteria, and the nitrifying bacteria. Refer to Figure 4-1 as you read the story.

A Story from the Underground

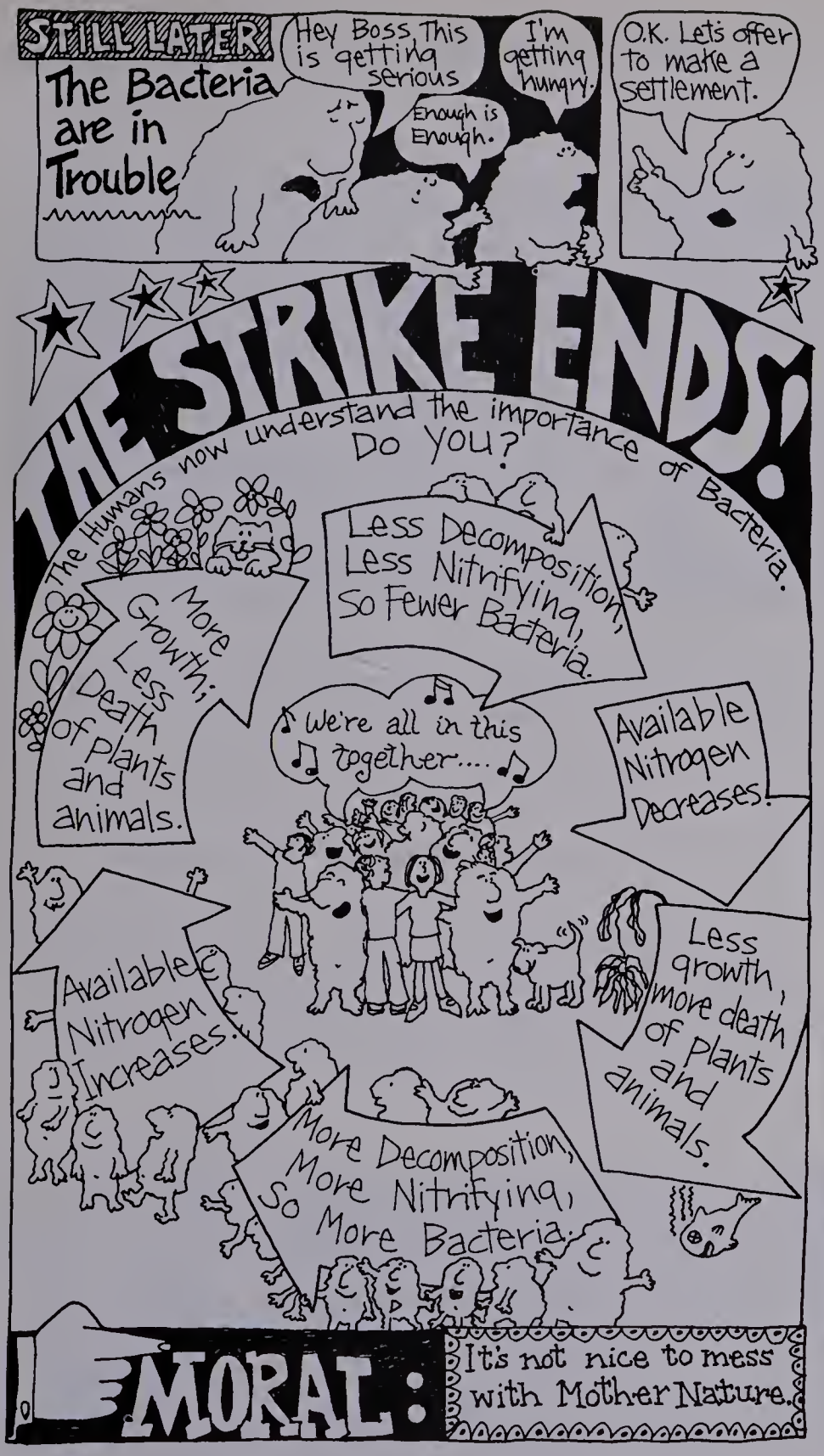
Three groups of bacteria have banded together in protest over their bad image. People are mistaking them for disease-causing bacteria.

★ **4-1. Which kinds of bacteria recycle nitrogen so that other organisms can use it?**



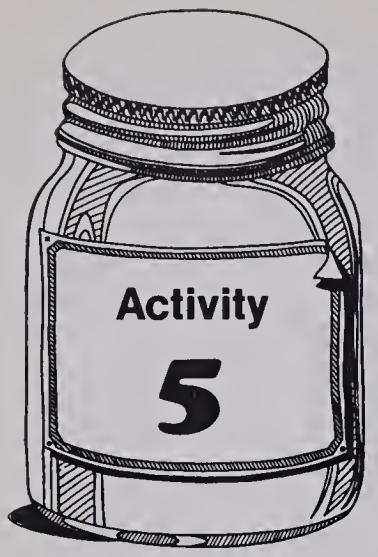
✔ 4-2. Legumes such as soybean plants have nitrogen-fixing bacteria on their roots. Wheat and some other plants do not. Some farmers plant wheat one year and legumes the next. Why do farmers rotate crops this way?

★ **4-3. Suppose people got rid of all decomposers, nitrifiers, and nitrogen-fixers. What do you think would happen?**



Have you checked your food containers today? Be sure to record your observations.

✔ 4-4. The diagram shows that the amount of nitrogen in the cycle stays about the same. Explain.



Preserving by Drying

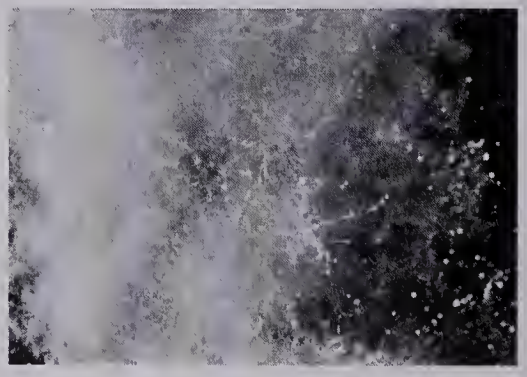
Preserving food means protecting it from spoilage. Food can be spoiled by microorganisms—bacteria, yeasts, and molds—that grow in food. If you want food to keep, you've got to protect it from these natural enemies.

Bacteria, molds, and yeasts take in food materials that are dissolved in water. These microorganisms can't feed unless water is present; they need moisture to survive. Many foods are 80% to 95% water. Meat, eggs, vegetables, fruit, and milk are good places for microorganisms to grow and reproduce.

★ **5-1. Why do microorganisms live in moist places?**

Drying food is one way to preserve it. This method takes out enough water to prevent the growth of food-spoiler microorganisms. When foods are dried, water is drawn out of the food and out of the food spoilers. As they lose water, some organisms die and some form spores. If it can form a spore, the organism "rests" until conditions get better.

bacteria spores, magnified



bread-mold spores, magnified

spores of a common mold, magnified

Some foods are naturally so dry that they are preserved. Other foods are preserved when people dry them. Fruits, some vegetables, and some fish are preserved by drying. These foods are simply set out in the sun.

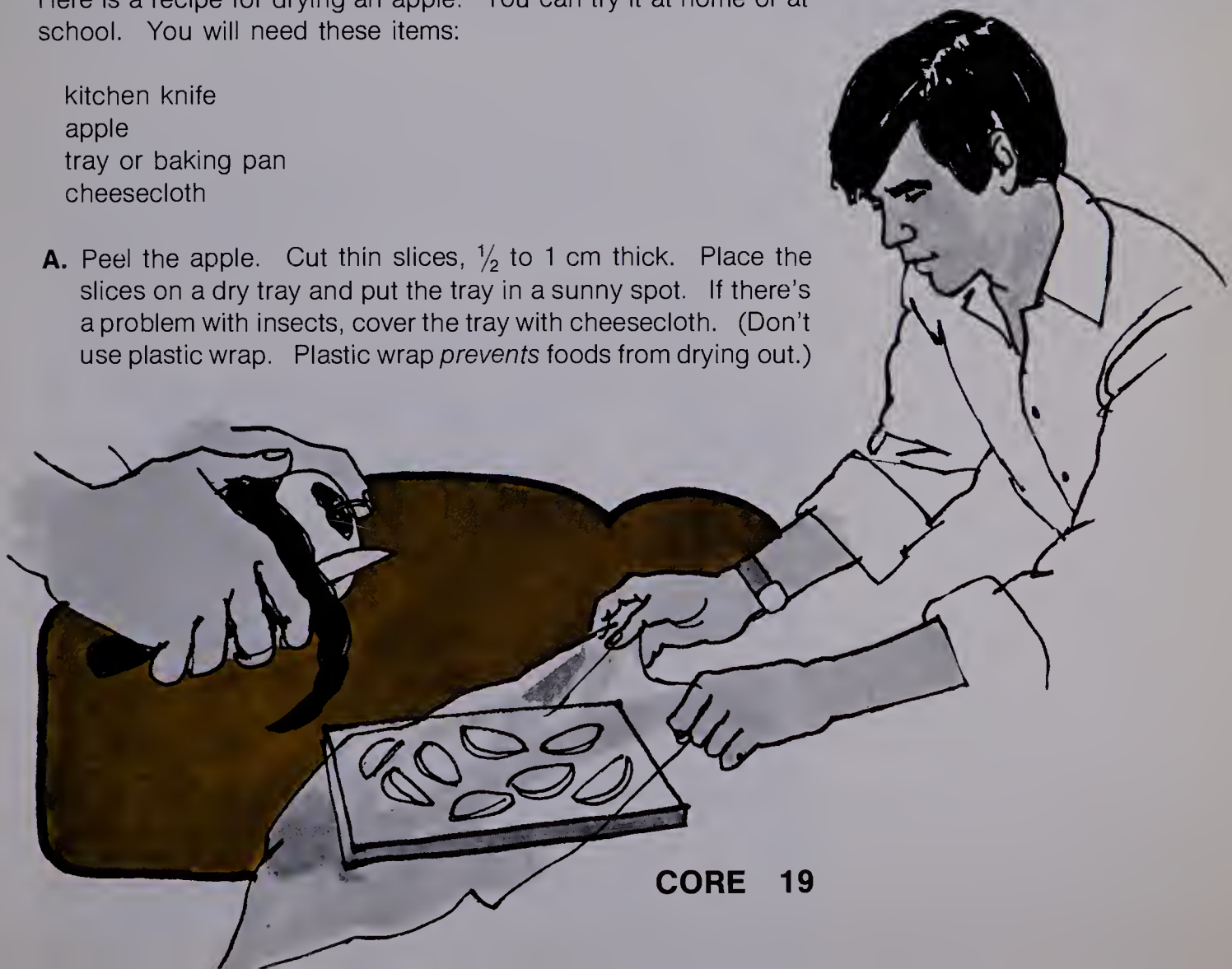
coffee beans drying in the sun

fish drying in the sun

Here is a recipe for drying an apple. You can try it at home or at school. You will need these items:

kitchen knife
apple
tray or baking pan
cheesecloth

A. Peel the apple. Cut thin slices, $\frac{1}{2}$ to 1 cm thick. Place the slices on a dry tray and put the tray in a sunny spot. If there's a problem with insects, cover the tray with cheesecloth. (Don't use plastic wrap. Plastic wrap *prevents* foods from drying out.)



B. Turn the slices every day so they will dry evenly. With low humidity and much sunshine the drying should take no longer than 3 days.

Observe the apple slices each day. Record their color, texture, aroma, weight, etc.

★ 5-2. Why is air-drying a good way to preserve some foods?

Centuries ago, people learned a faster way to dry meat and fish. The food was placed over wood fires. The slow-burning fires produced smoke as well as heat. Although the method was called smoking, it was the heat that preserved the food.

Meat, fish, and other foods can be dried another way. These foods are treated with salt or sugar. Ham and bacon are "sugar-cured"; fish is often salted.

Salt and sugar cause drying. You can see this by doing the following investigation. You will need these items:

2 pieces of potato
grease pencil
2 containers with lids, such as baby-food jars or petri dishes
salt
sugar

A. Label one container *salt*. Place one piece of potato in the container. Then completely cover the potato with salt. Label the second container *sugar*. Put a piece of potato inside and completely cover it with sugar.

B. Cover each container with a lid.

Record the size and appearance of each piece of potato at the end of the class. Record your observations again the next day.

✔ 5-3. How do you think the sugar or salt dried the potato?

✔ 5-4. What would happen to ham covered with sugar or salt? What would happen to microorganisms on or in the ham?

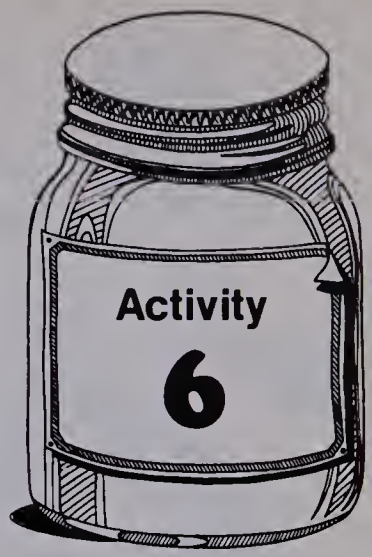
Sometimes foods are preserved in a sugar-water or salt-water solution. Just as with solid salt or sugar, the water in the food or in the microorganisms is drawn out. Cucumbers on the way to becoming crisp pickles are placed in salt water. Canned fruits are often packed in a sugar solution or syrup.

★ **5-5. In what three ways is water drawn from food?**

Find some dry-food products at home or in a supermarket. If you live near a farmers' market, look there too. You will see many dried foods on the shelves, unrefrigerated and without any packaging; others are bagged, boxed, or canned.

✔ 5-6. What foods are preserved by drying? Write what method was used for drying each food you list.

Preserving with Acid



You may think all pickles were once cucumbers. Well, many pickles were, but not all. Many other vegetables and some meats can also be pickled. There are pickled beets, pickled beans, pickled asparagus, pickled eggs, and pickled pigs' feet.

Here is a recipe for cucumber pickles that takes 3 days. It is called the short-brine method. You can try it at home or school.

Making Cucumber Pickles

CAUTION

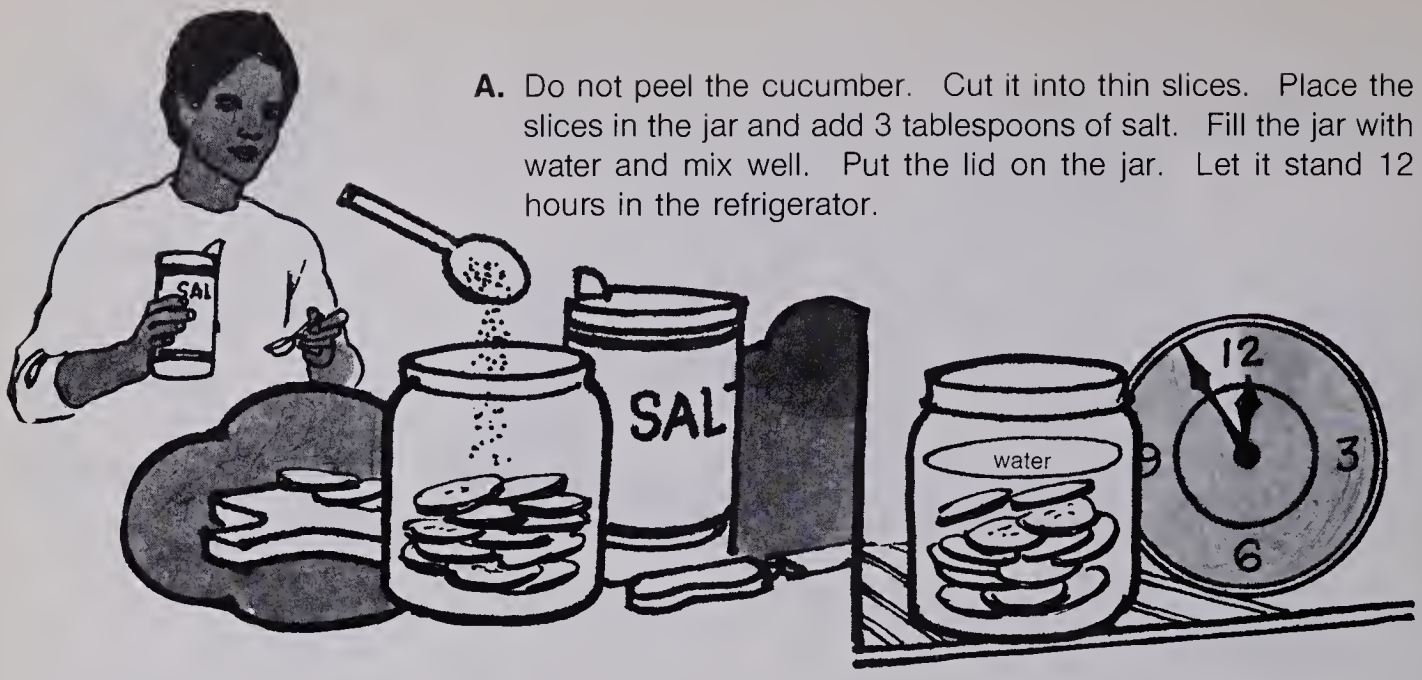
It is dangerous to keep these preserved pickles longer than a few days.

Eat the pickles as soon as they are ready. A different method is necessary for pickles that are to be preserved for a long period of time.

Before you begin, read through the entire recipe. You will need these items:

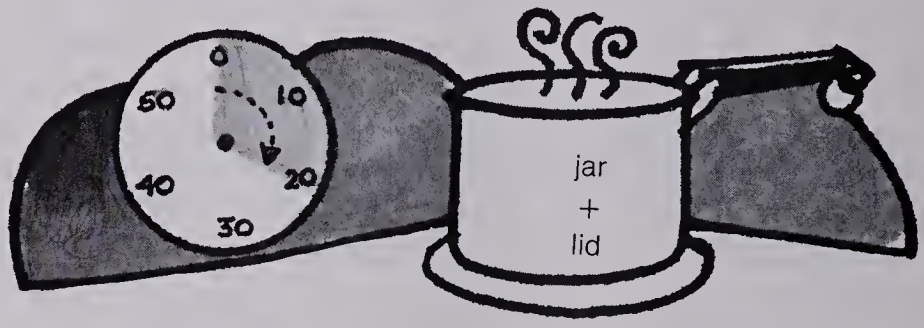
kitchen knife
one or more cucumbers, firm, without bruises, and well scrubbed
pint jar and lid
3 tablespoons salt
measuring spoons and cups
spoon, stainless steel, enamel-covered, or wooden
refrigerator
1½ cups vinegar
beaker, or saucepan of stainless steel or enamel
1½ cups sugar
saucepan, for sterilizing jar and lid
stove or electric hot plate
tongs
watch or other timer

This recipe is for fairly sweet pickles. The amount of sugar can be varied according to taste.

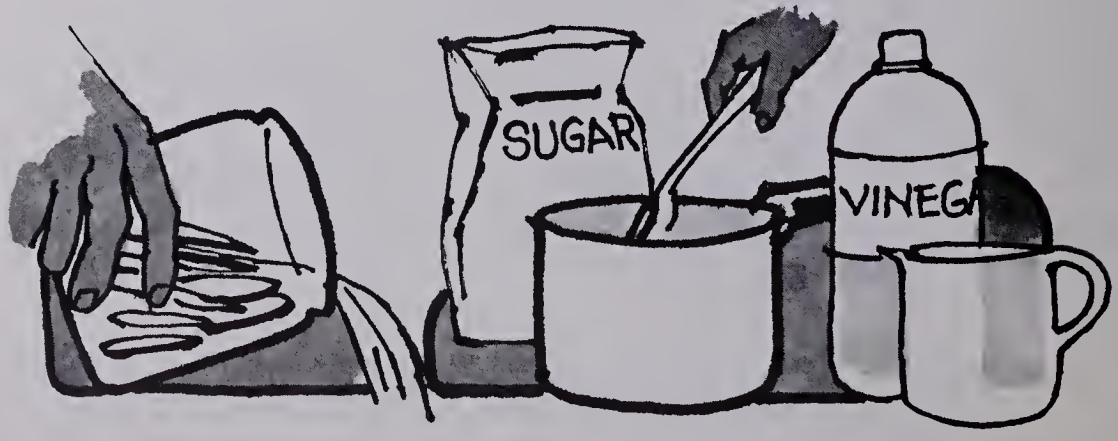


A. Do not peel the cucumber. Cut it into thin slices. Place the slices in the jar and add 3 tablespoons of salt. Fill the jar with water and mix well. Put the lid on the jar. Let it stand 12 hours in the refrigerator.

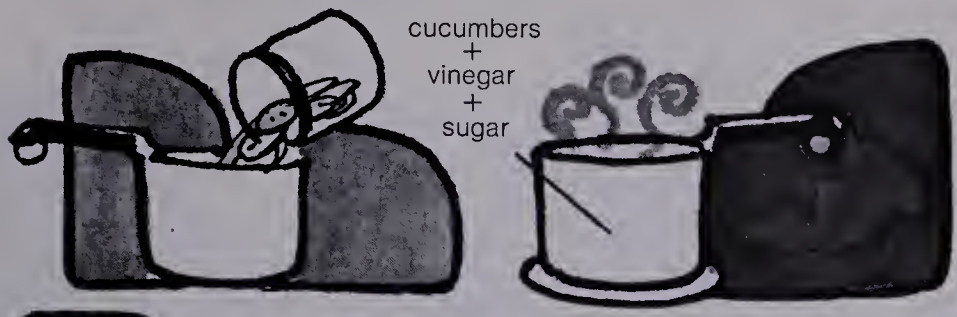
B. The next day, put the empty pickle jar and lid into a saucepan of water. Don't leave the lid on the jar. Sterilize the jar and lid by boiling them for 20 minutes. Also sterilize a spoon that you may need in Step F.



C. Drain the salt water, or brine, from the cucumber slices. Put 1½ cups of vinegar in the beaker, or stainless steel or enamel saucepan. Add 1½ cups of sugar and stir to dissolve the sugar.



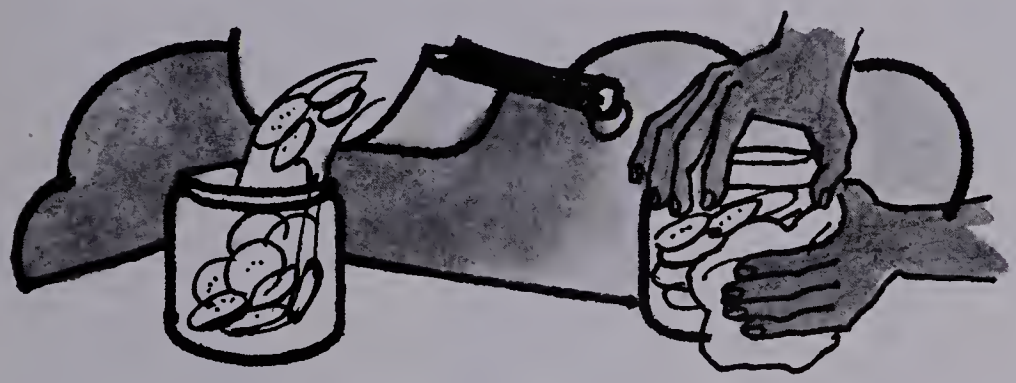
D. Without splashing, add the cucumber slices to the vinegar-sugar mixture. Cook over medium heat just until the vinegar-sugar-cucumber mixture starts to boil.



IMPORTANT: Work quickly on the next three steps in which the food and the sterilized jar are exposed to the air.

E. Use tongs to remove the jar from the water. Don't touch the inside of the jar with your hands.

F. Pour the hot vinegar-sugar-cucumber mixture into the jar. Don't touch the mixture or the inside of the jar. If necessary, use a sterilized spoon. Remove the lid from the water, put it on the jar, and tighten it. Set the jar aside for 1 day.



Now eat and enjoy your pickles. Be sure to eat them in the next few days. You can make a different kind of pickle using a long-brine recipe in Activity 18.

Acids, such as vinegar, are used to protect food from bacteria. You used vinegar to protect your cucumbers. Vinegar is also used to preserve onions, beets, herring, sardines, and other low-acid foods. Some foods have a built-in preservative. Those foods that are naturally very acidic keep better than those that aren't. The pH of a food tells how acidic it is.

✔ 6-1. What is the pH of a strong acid? Of water?

If you can't answer Question 6-1, review *Resource Unit 7.*

Figure 6-1 shows the pH of a variety of uncooked foods. It also shows that bacteria usually grow on foods that have a pH of 4.0 or higher. Molds and yeasts grow on foods even higher in acid.

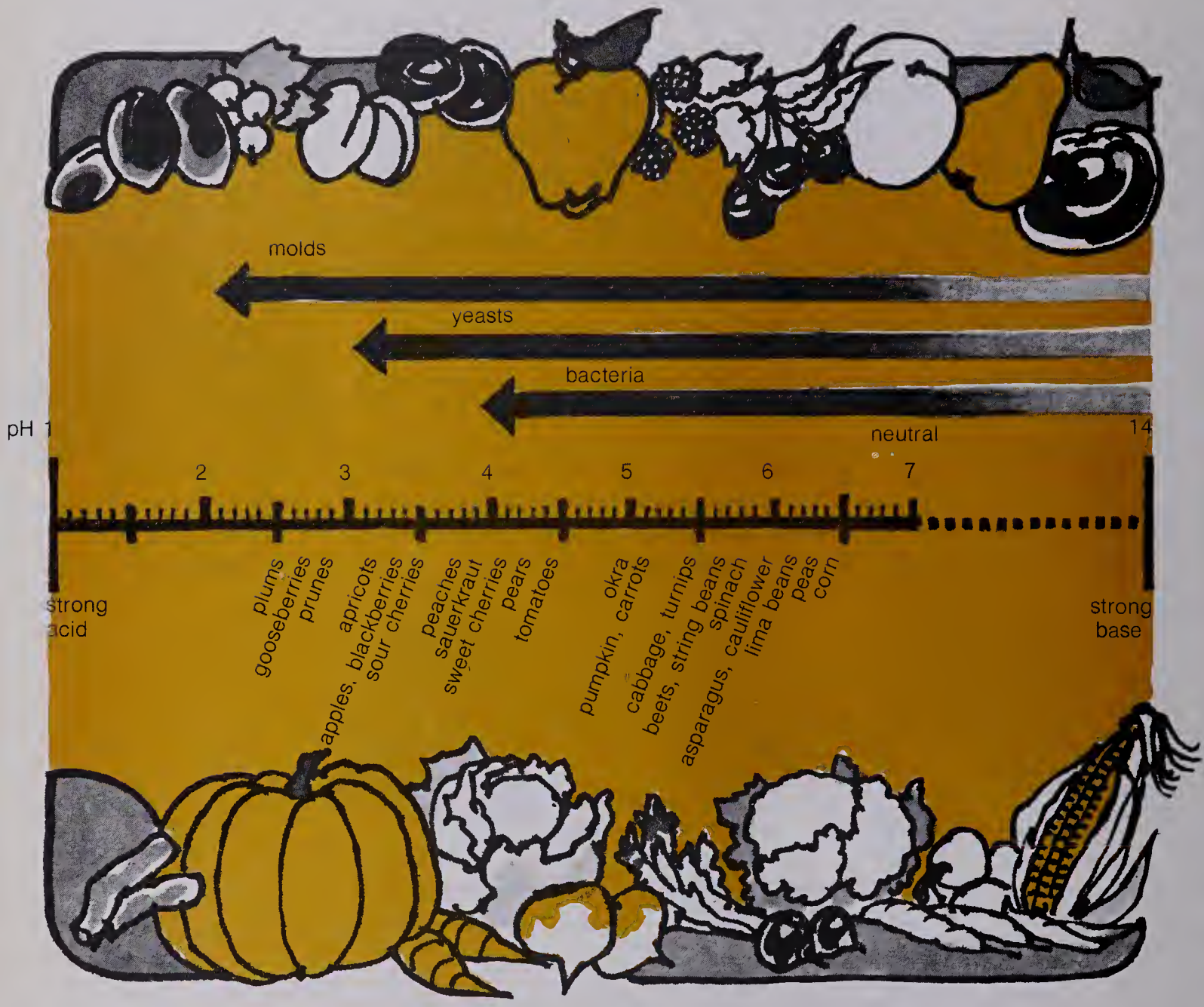
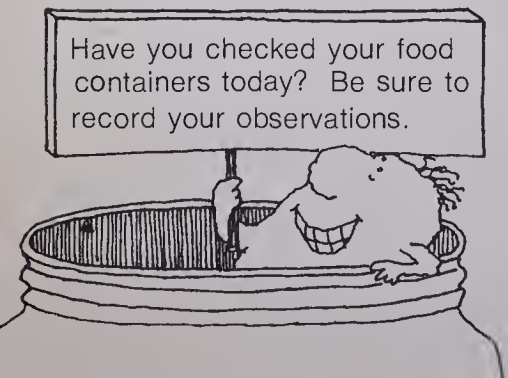


Figure 6-1

★ **6-2. Will bacteria grow on peaches? Explain by referring to the pH of peaches, shown in Figure 6-1.**



★ **6-3. Given the pH of plums, what kind of microorganism will grow on them?** (See Figure 6-1.)

★ **6-4. Are bacteria more likely to cause fruits or vegetables to spoil?** (See Figure 6-1.)

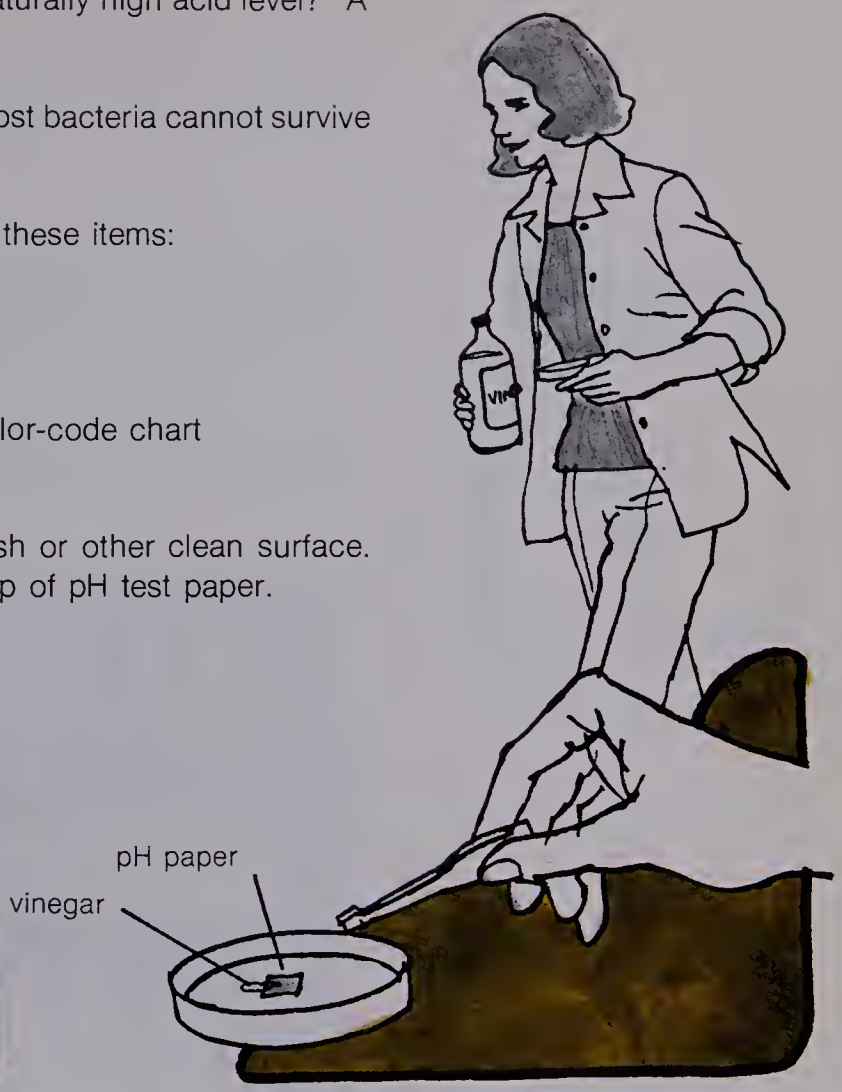
✔ 6-5. What kinds of foods have a naturally high acid level? A naturally low acid level?

A close look at Figure 6-1 shows that most bacteria cannot survive at a pH level of 4.0 or lower.

Find out the pH of vinegar by using these items:

vinegar
medicine dropper or toothpick
petri dish or other clean surface
pH test paper and dispenser with color-code chart
forceps or tweezers

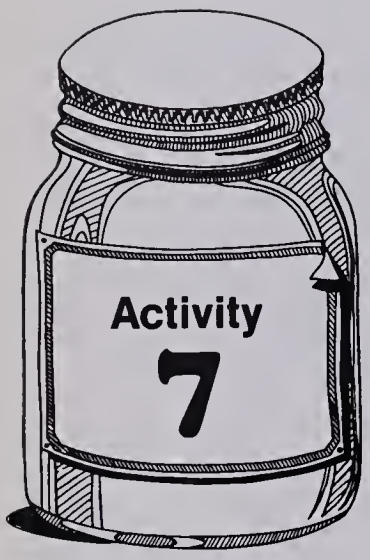
A. Put a drop of vinegar on a petri dish or other clean surface. Test the drop with a fresh 1-cm strip of pH test paper.



B. Compare the color of the pH paper to the color-code chart on the dispenser. The color-code chart will indicate just how acidic vinegar is.

✔ 6-6. What is the pH of vinegar?

★ **6-7. Which microorganisms are most affected when vinegar is used in pickling?** (See Figure 6-1.)



Food Additives

Many chemicals, both natural and artificial, are put into foods. The chemicals are called *additives*. There are many reasons for adding these chemicals to foods. Some additives protect foods from spoilers—molds, yeasts, and bacteria.

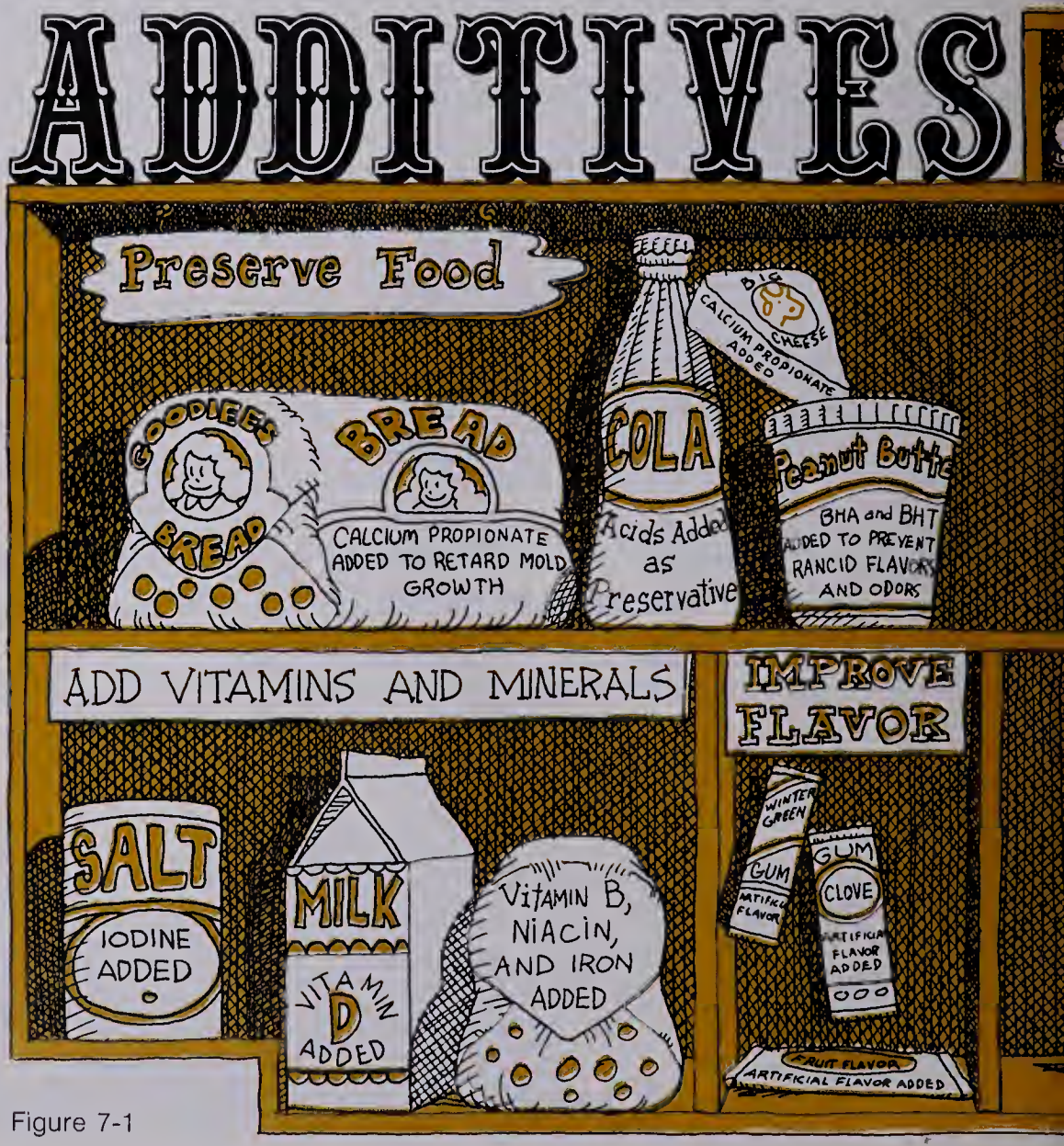


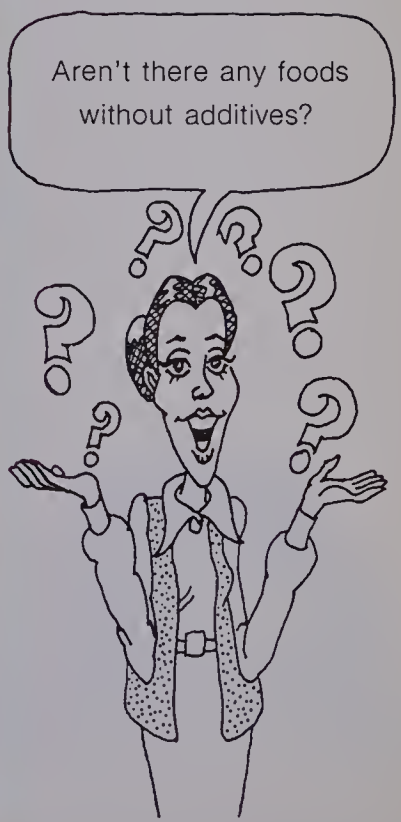
Figure 7-1

Salt is an additive used to prevent food spoilage. In fact, salt may have been the first additive ever used. Primitive people learned to use it to preserve meat and fish. Even today people continue to use spices to preserve, and flavor, foods. Figure 7-1 shows the many ways additives are used.

✔ 7-1. What foods often contain several additives? (Use Figure 7-1 to help you answer.)

★ **7-2. According to Figure 7-1, why are acids added to foods?**

★ **7-3. What are two ways to lengthen the shelf life of foods?** (See Figure 7-1.)



About 3000 different additives are put in foods by manufacturers in the United States. Although only small amounts of each chemical are present in each food, the total can add up. You consume about 1.8 kilograms (4 pounds) of additives every year.

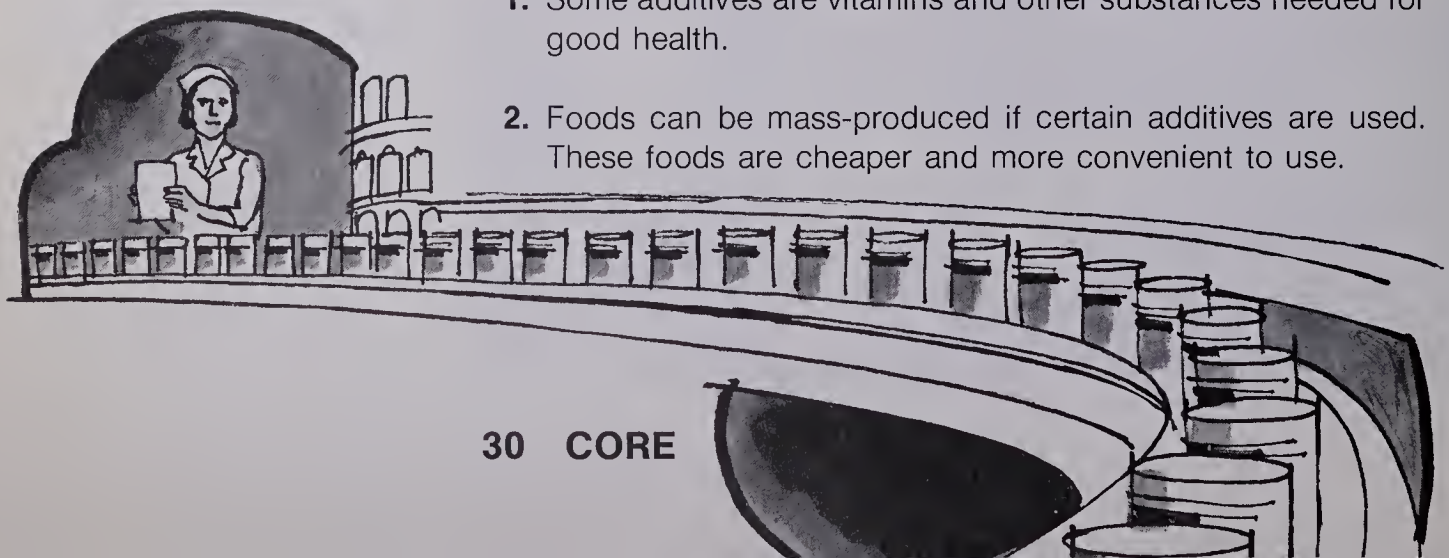
Can food manufacturers add anything they want to the food they process? No! There are federal laws that set standards. All additives must be approved by a government agency, the Food and Drug Administration (FDA). When food producers want to put an additive into food, they must give the FDA proof that the additive is not harmful and that the additive serves its desired purpose.

The FDA publishes a list of additives generally recognized as safe. But some additives were first put in foods before the laws were passed. Some of these substances are now being tested.

The following statements show some arguments for and against the use of additives. The arguments for and against are mixed together.

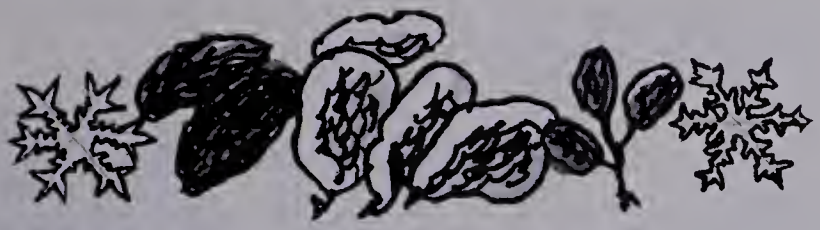
1. Some additives are vitamins and other substances needed for good health.

2. Foods can be mass-produced if certain additives are used. These foods are cheaper and more convenient to use.



3. Some additives are added so foods can be mass-produced and stored. These additives have no nutritional value.

4. Some additives help to preserve foods. Then these foods are available all year, and not just for a few months.



5. Some additives cause allergic reactions in certain people. Monosodium glutamate (MSG) is an example of such an additive.

6. Some additives improve the flavor of foods. And some are substitutes for natural flavorings that are not plentiful. There is not much natural flavor in ice cream, for example.

7. Many additives are found naturally in foods. For example, Swiss cheese naturally contains the same additive used in other cheeses to prevent mold growth.

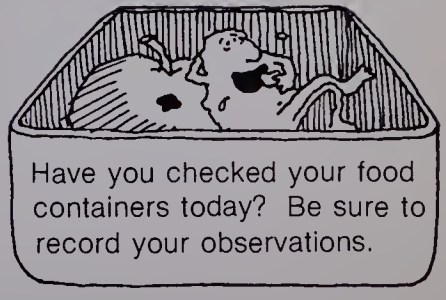
8. Many additives approved by the FDA have not yet been tested to see their effect on health after years of use.

9. Additives are usually tested on laboratory animals. But those animals may not respond in the way people do. And people don't all respond the same way.

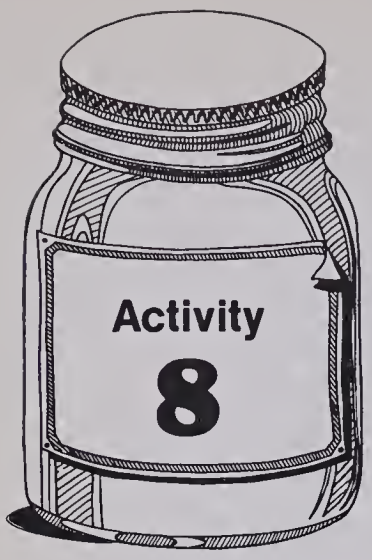
10. Tests show that many additives are not harmful. If found unsafe, an additive is taken off the market.

★ **7-4. What are some arguments for the use of additives? Against the use of additives?**

★ **7-5. In your opinion, which is (are) the best argument(s) for using food additives? Against using food additives?**



Have you checked your food containers today? Be sure to record your observations.



Food Poisoning

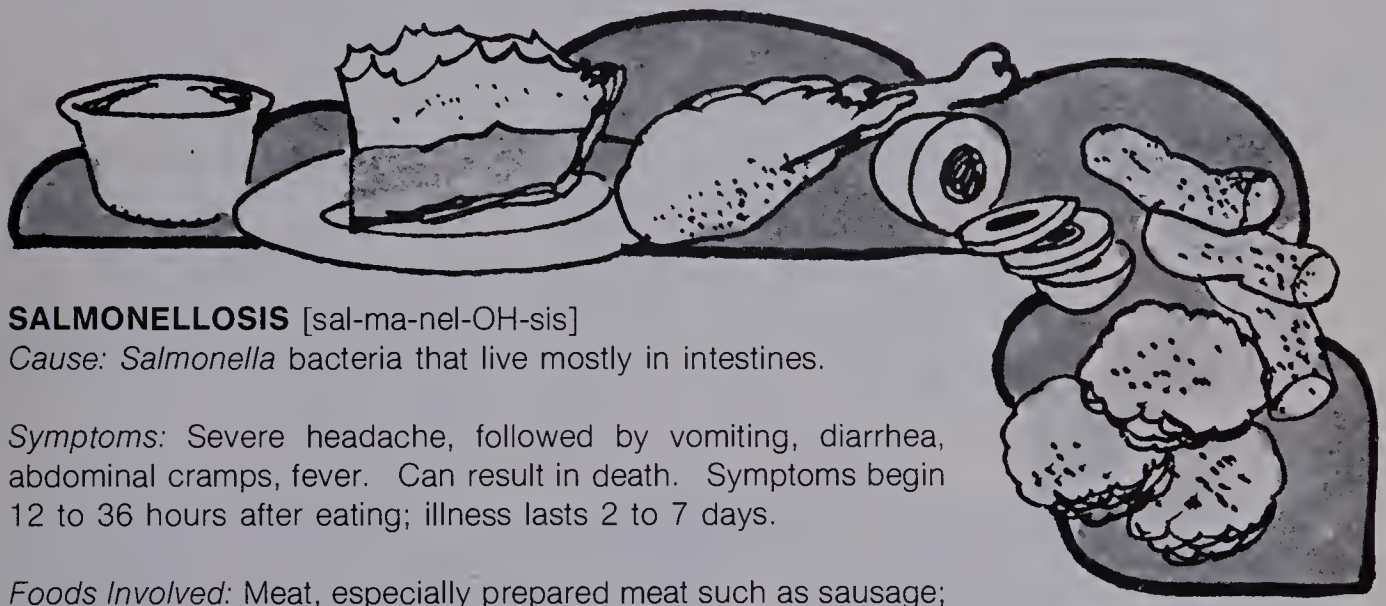
Food poisoning is no fun! And it happens more often than most people realize. Food poisoning is usually not caused by chemicals that get into food. It's usually due to certain bacteria that get into food.

Not just any bacteria will make you sick. Some bacteria make food smell or taste bad, but these generally don't cause food poisoning. The dangerous bacteria usually don't change the taste or smell of food. They can cause illness in two ways. Some, like Salmonella, cause illness by reproducing in your digestive tract.

Other bacteria can cause illness by producing toxins, or poisons. Staphylococcus [staf-low-KOK-us] bacteria produce a toxin as they reproduce in foods such as cream pies and eclairs. The bacteria may be killed when the pastry is baked, but the poisonous toxin remains. The toxin is colorless and odorless, but it's powerful and can cause harm.

★ **8-1. What are two causes of food poisoning?**

You can't tell just by taste or smell whether poisonous bacteria are present in your food. It's only after getting sick that you find out that you have eaten "poisoned" food. The best way to prevent food poisoning is to prepare and store food properly. The information that follows describes four kinds of poisoning.



SALMONELLOSIS [sal-ma-nel-OH-sis]
Cause: Salmonella bacteria that live mostly in intestines.

Symptoms: Severe headache, followed by vomiting, diarrhea, abdominal cramps, fever. Can result in death. Symptoms begin 12 to 36 hours after eating; illness lasts 2 to 7 days.

Foods Involved: Meat, especially prepared meat such as sausage; poultry; egg products—custards, egg salad, meringue.

Prevention: Store food at refrigerator temperatures (5°C) to prevent growth of bacteria. Reheat food thoroughly (almost to a boil) for 10 minutes to kill bacteria.

PERFRINGENS POISONING [per-FRIN-jens]
Cause: Clostridium perfringens, a bacterium that does not need oxygen to live and can survive cooking temperatures.

Symptoms: Nausea without vomiting; diarrhea; abdominal cramps. Symptoms begin after 8 to 20 hours; illness lasts up to 24 hours.

Foods Involved: Gravies, meat pies, casseroles, stews.

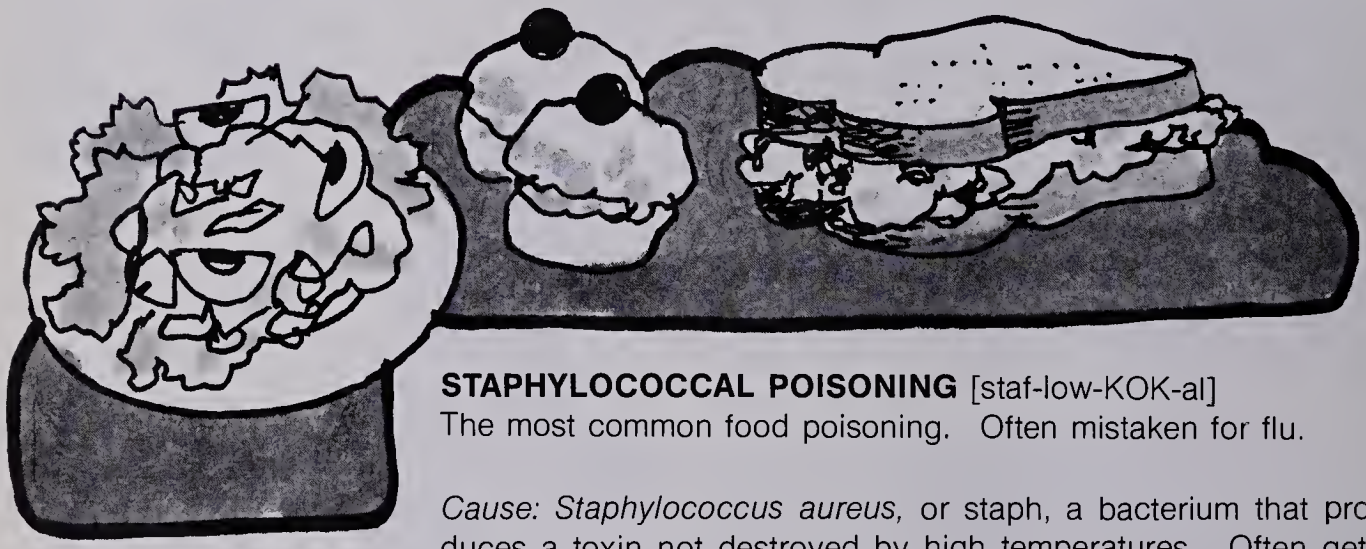
Prevention: Promptly refrigerate cooked food to prevent growth of bacteria that survive cooking temperatures.

BOTULISM [BOTCH-a-liz-um]
Cause: Clostridium botulinum, a bacterium that produces a toxin. Because it does not need oxygen, it can live in sealed cans or jars.

Symptoms: Double vision, difficulty in swallowing and speaking, gradual paralysis of breathing muscles. About 65% of people who get botulism die. Symptoms begin 12 to 36 hours after eating; for people who recover, illness lasts 3 to 6 days.

Foods Involved: Usually found in home-canned and occasionally in commercially canned foods.

Prevention: Bacterial spores can be killed only by commercial canning or by using a pressure cooker for home canning. The toxin, however, is destroyed by boiling food for 10 to 20 minutes. Discard cans with bulging lids. Do not taste the contents.



STAPHYLOCOCCAL POISONING [staf-low-KOK-al]
The most common food poisoning. Often mistaken for flu.

Cause: Staphylococcus aureus, or staph, a bacterium that produces a toxin not destroyed by high temperatures. Often gets into food from an infection, a cough, or sneeze.

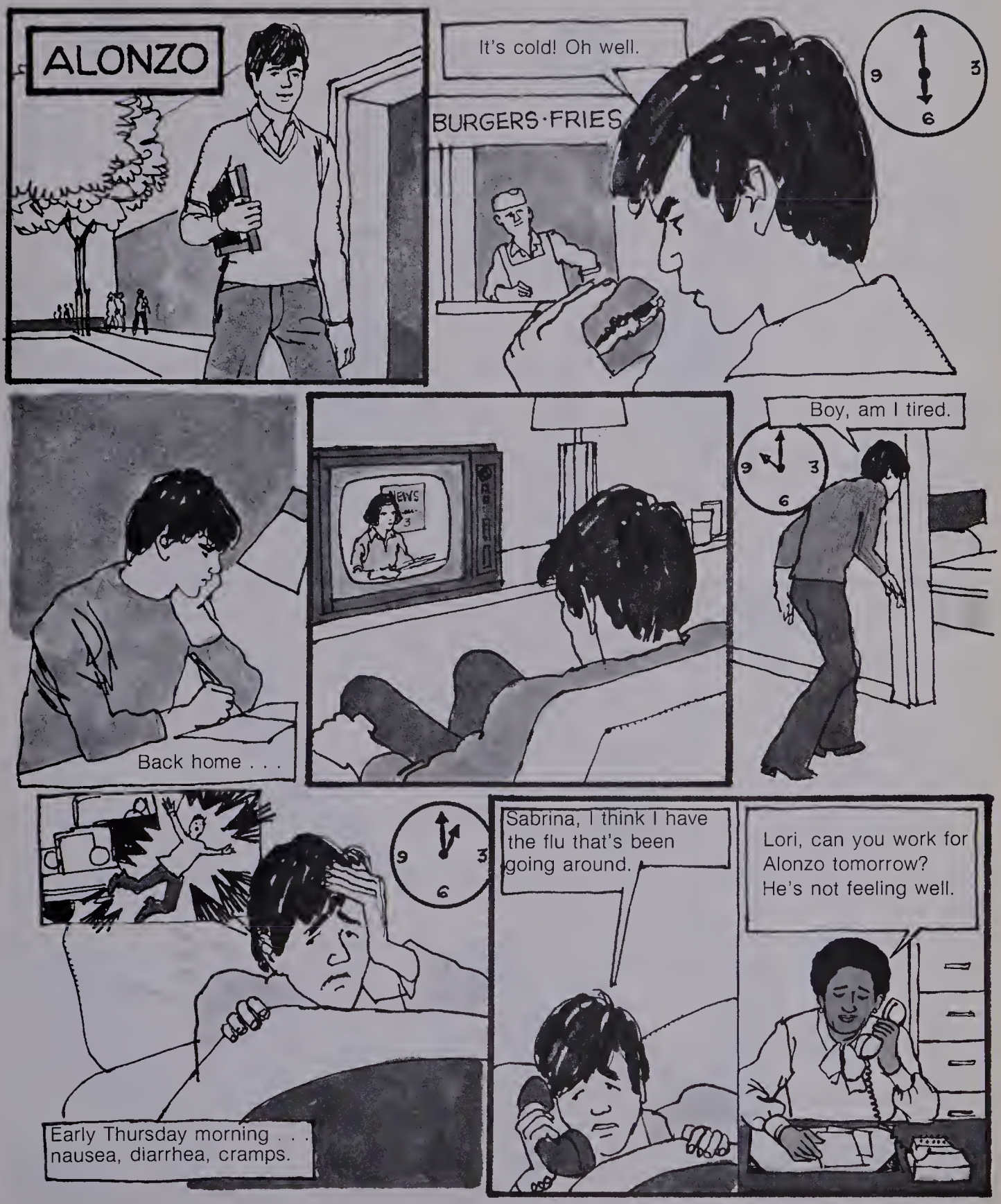
Symptoms: Vomiting, diarrhea, abdominal cramps, nausea. Symptoms are generally mild. They begin within 3 to 8 hours after eating; illness lasts 1 to 2 days.

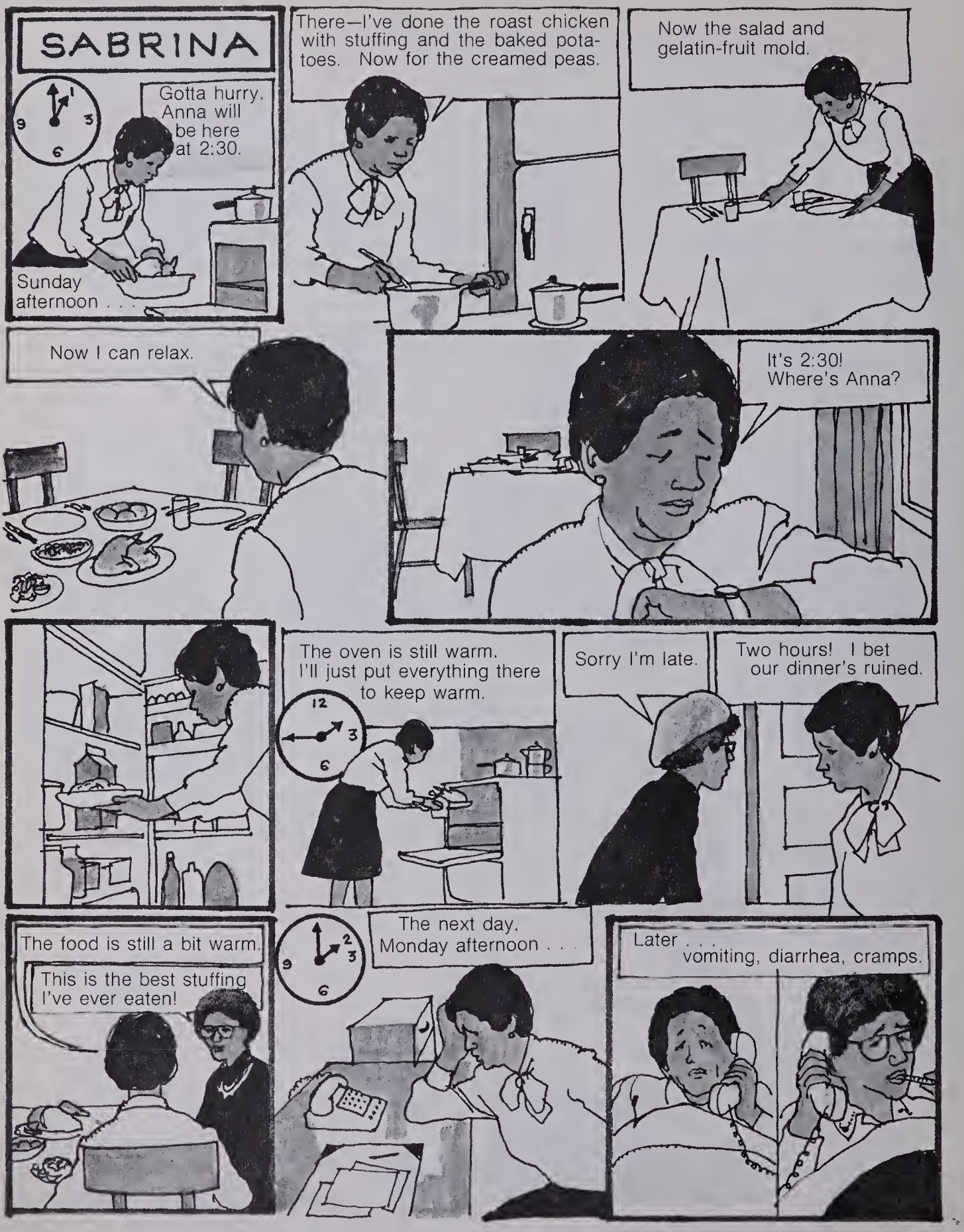
Foods Involved: Pastries, custards, salads, sandwiches, chicken salad, especially prepared foods containing mayonnaise.

Prevention: Keep hot foods hot (above 60°C) and refrigerate cold foods. The toxin is not destroyed at boiling temperatures (100°C), unless boiling is continued for several hours.

★ **8-2. What are three common symptoms of food poisoning?**

Are you almost an expert on food poisoning now? Read the two stories that follow and test your ability to make a diagnosis.




SABRINA
Gotta hurry. Anna will be here at 2:30.
Sunday afternoon . . .
There—I've done the roast chicken with stuffing and the baked potatoes. Now for the creamed peas.
Now the salad and gelatin-fruit mold.
Now I can relax.
It's 2:30! Where's Anna?
The oven is still warm. I'll just put everything there to keep warm.
Sorry I'm late.
Two hours! I bet our dinner's ruined.
The food is still a bit warm.
This is the best stuffing I've ever eaten!
The next day. Monday afternoon . . .
Later . . . vomiting, diarrhea, cramps.

✔ 8-3. What could have made Alonzo sick?

✔ 8-4. Do Alonzo's symptoms match those for a type of food poisoning? If so, which type?

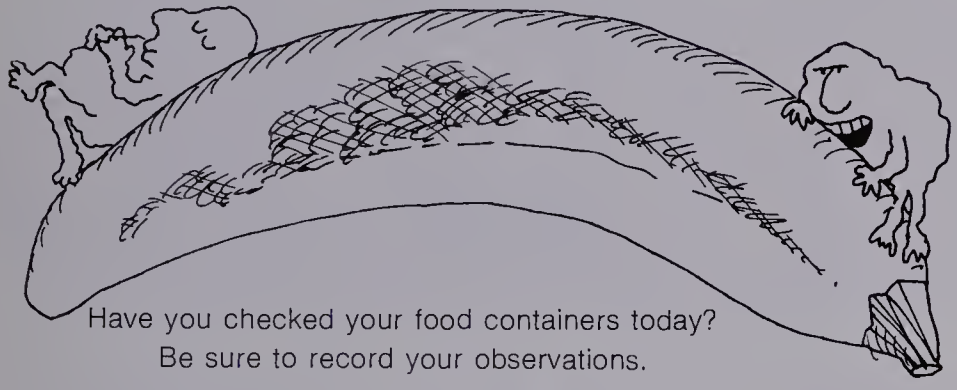
✔ 8-5. Do you think Alonzo will still be sick on Saturday night? Explain.

✔ 8-6. What do you think is wrong with Sabrina and Anna?

✔ 8-7. What do you think has caused their illness?

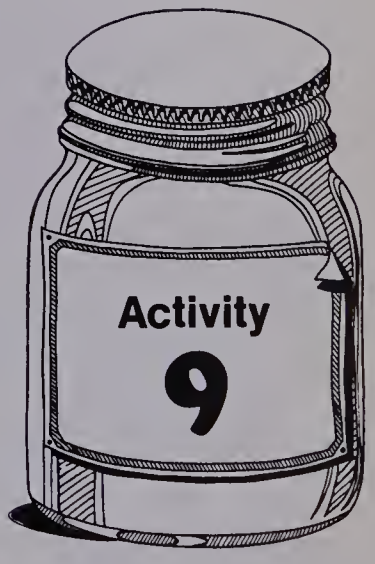
✔ 8-8. What would you do to prevent the same thing from happening to you?

Activities 5, 6, 9, and 11 in this minicourse also tell you how to protect food from food-poisoning bacteria.



Have you checked your food containers today?
Be sure to record your observations.

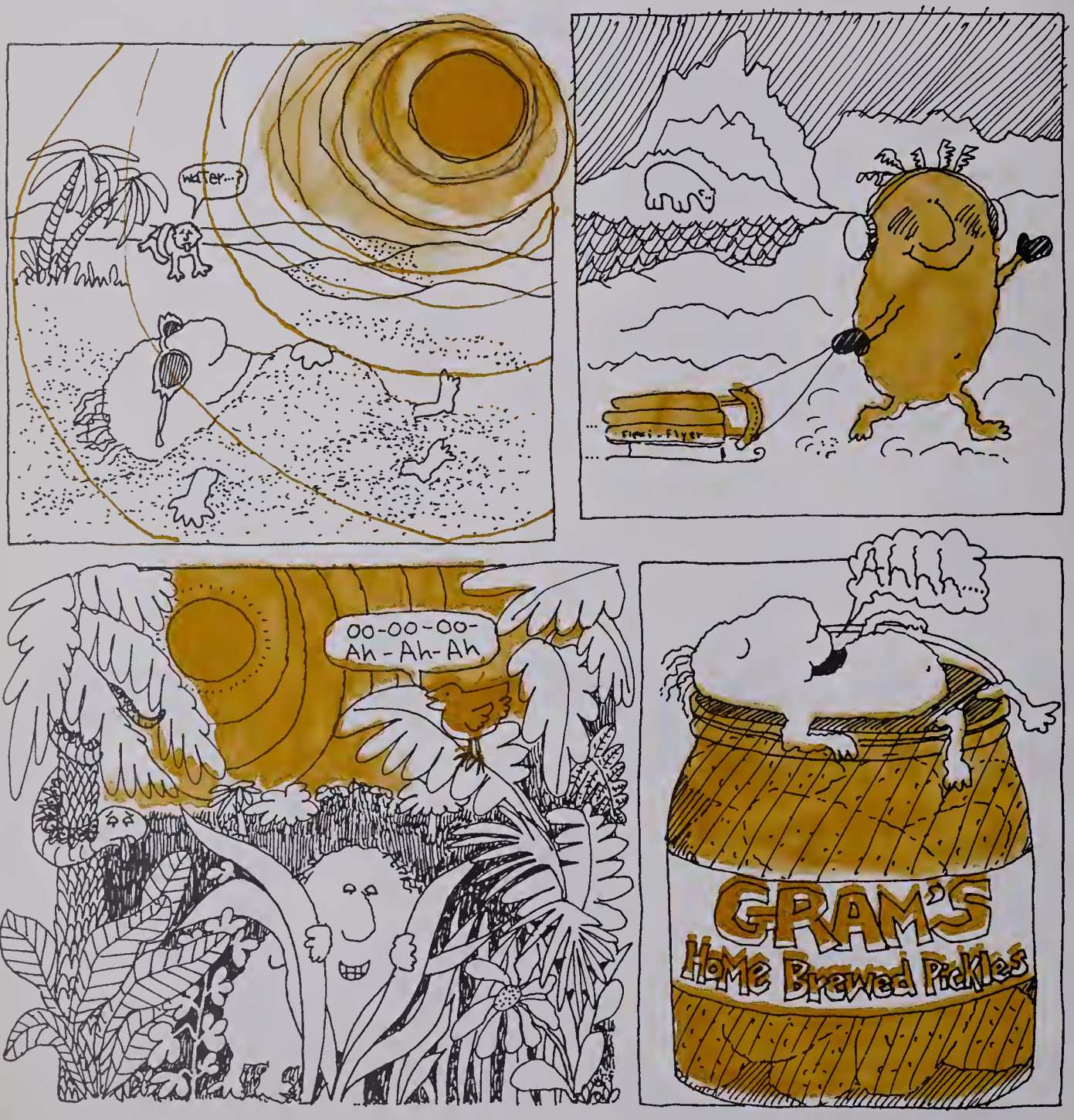
Preserving with Heat and Cold



Why do people cook and refrigerate foods? Of course to improve the flavor, but there are other reasons. Foods are good places for bacteria, yeasts, and molds to grow. Both cooking and refrigeration help to control the growth of these food spoilers.

Like other living things, food spoilers live where the temperature is favorable to them. Some grow and reproduce at only certain temperatures; they die if the temperature rises or falls only a few degrees. Other spoilers live at a wide range of temperatures. In this activity, you'll find out how temperature affects the microorganisms that you started in Activity 2.

Bacteria, yeasts, and molds have a special way to survive at unfavorable temperatures. Suppose some bacterial cells begin to grow in a glass of milk. Then the glass of milk is put back into the refrigerator. A spore may form inside each bacterial cell. Within the spore, the food spoiler "hibernates." The spore does not grow. Inside, the spoiler "rests" until the temperature is warmer. Then the bacterial cell begins to grow and reproduce again. Spores help microorganisms survive in places that are too hot, too cold, too dry, or too acidic.



THE EFFECT OF TEMPERATURE ON BACTERIA, YEASTS, MOLDS

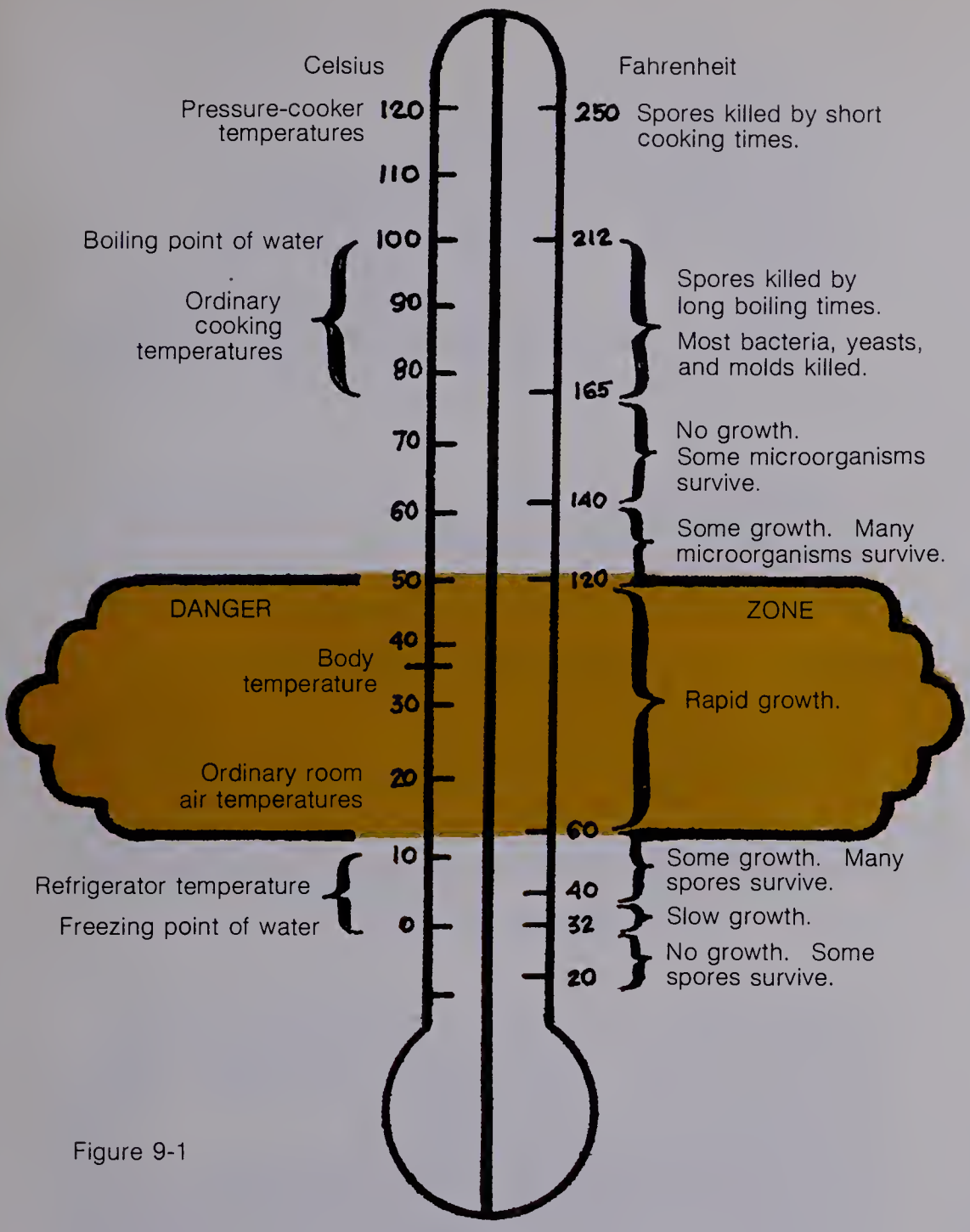


Figure 9-1

The effect of temperature on bacteria, yeasts, and molds is shown in Figure 9-1.

★ **9-1. How can you kill the spores in food?** (See Figure 9-1.)

★ **9-2. At what low temperature does little or no growth of microorganisms occur?** (See Figure 9-1.)

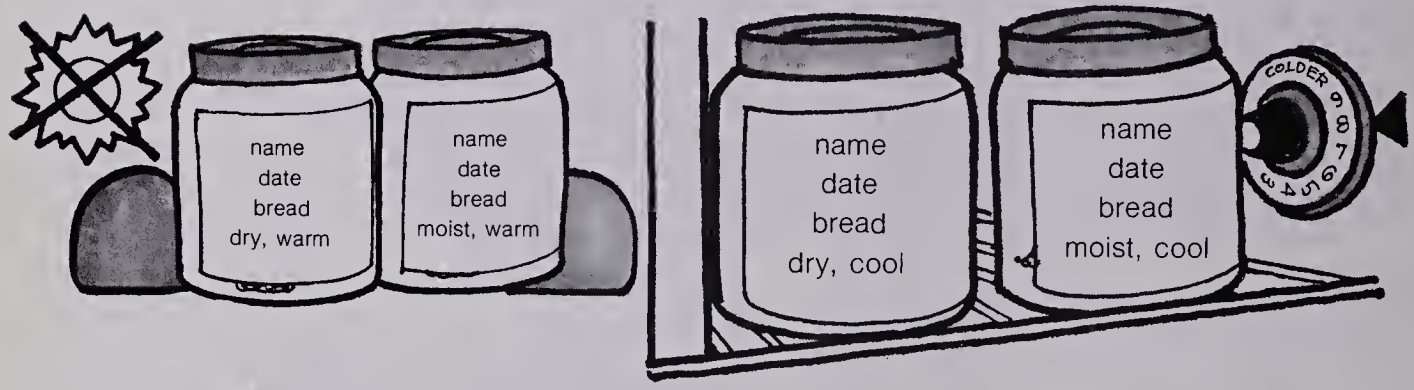
In *Activity 2: Getting Started,* you put a small piece of bread in four containers. You stored two in a warm place and two in a cool place. Take a look at your containers, but don't lift the covers!

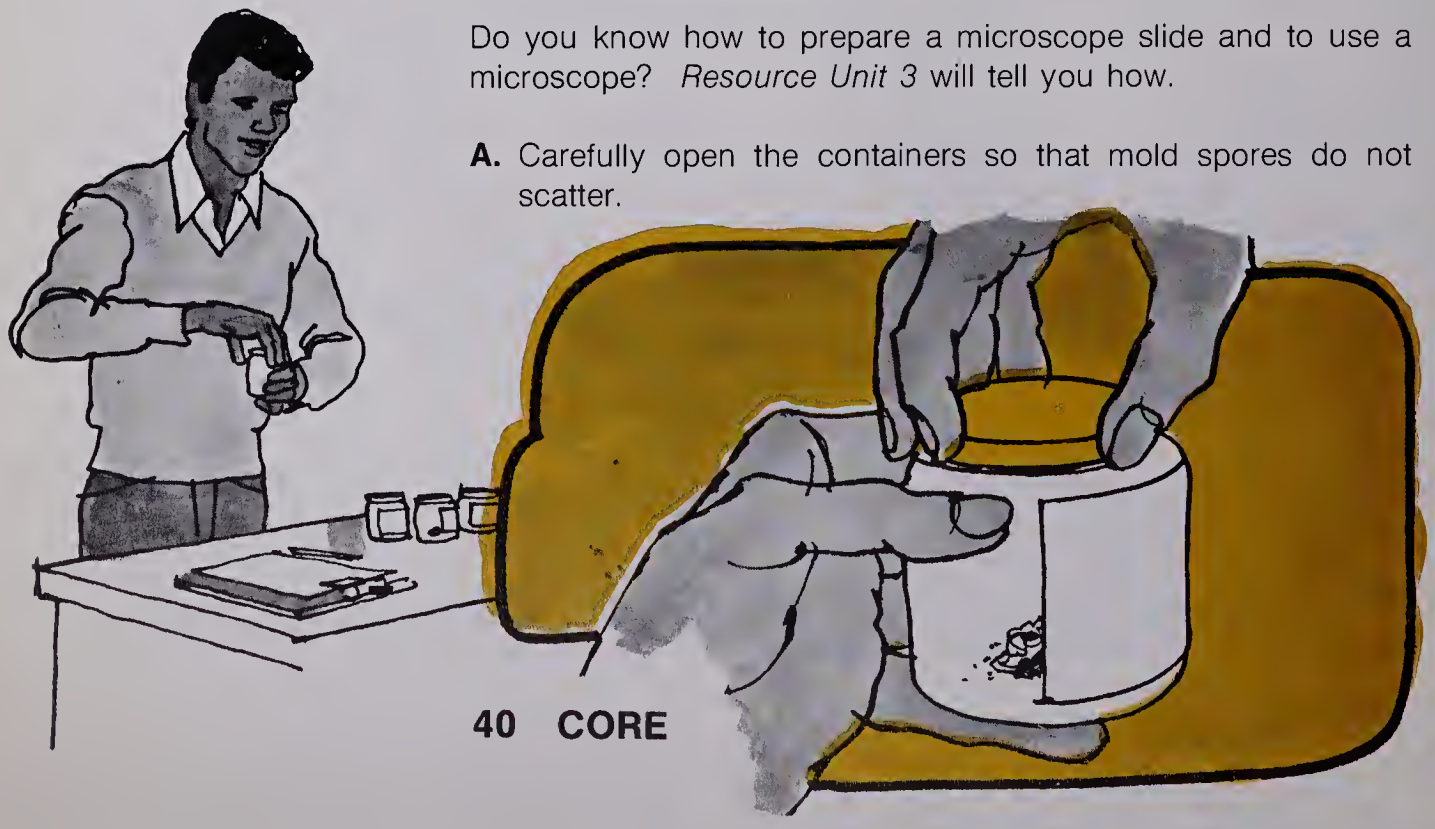
If you see nothing growing on the bread, leave the containers for 2 or 3 more days. Wait until some food spoilers start to grow in at least one container. Then continue this activity.

✔ 9-3. What kind of growth do you find on the bread? Describe its color and texture.

The most common bread spoiler is bread mold. Bread mold is probably growing in one or more of your jars. Take a close look at a tiny piece of the mold. You will need the following items:

1 or more of your containers
toothpicks
microscope slide and cover slip
microscope

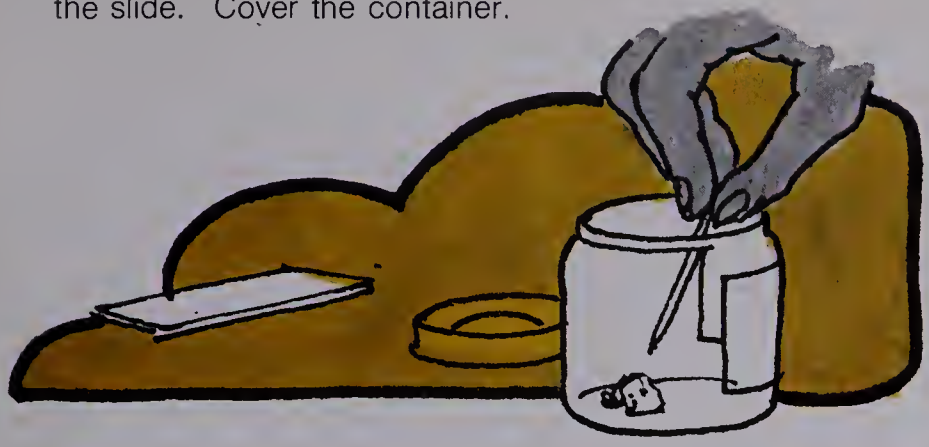




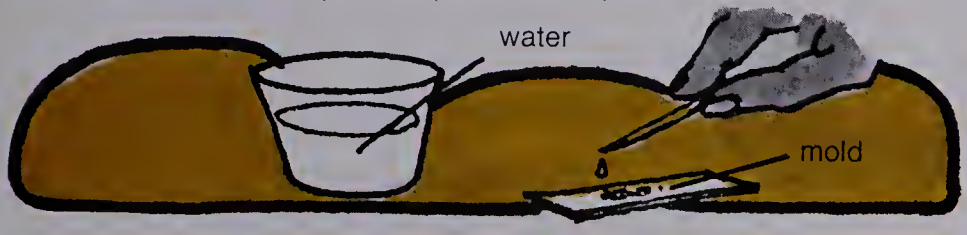
Do you know how to prepare a microscope slide and to use a microscope? *Resource Unit 3* will tell you how.

A. Carefully open the containers so that mold spores do not scatter.

B. Use a toothpick to pick up a small piece of mold and place it on the slide. Cover the container.

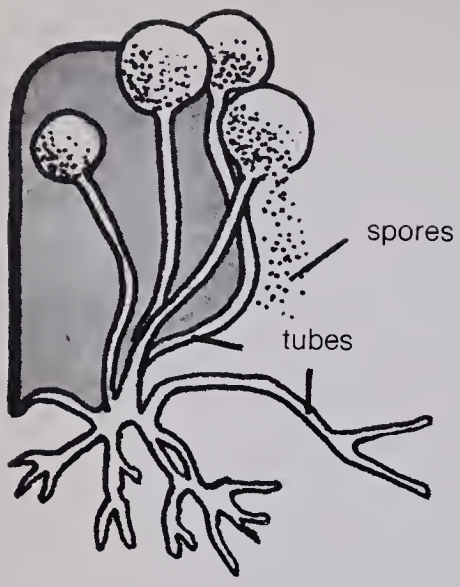


C. Use a clean toothpick to place a drop of water on the mold.



D. Carefully lower the cover slip at an angle.

E. Place the slide on the microscope stage. Look at the mold under low and high power.



The cottonlike fuzz is made up of very fine tubes. These tubes run throughout the bread. They release chemical substances, called *enzymes,* that digest the bread. The digested food passes into the tubes to feed the mold.

You may see spores on the tips of some of the tubes. If not, wait a few days, make a new slide, and look again.

✔ 9-4. Which of your four containers has the most mold?

✔ 9-5. What set of conditions seems to be best for the growth of mold?

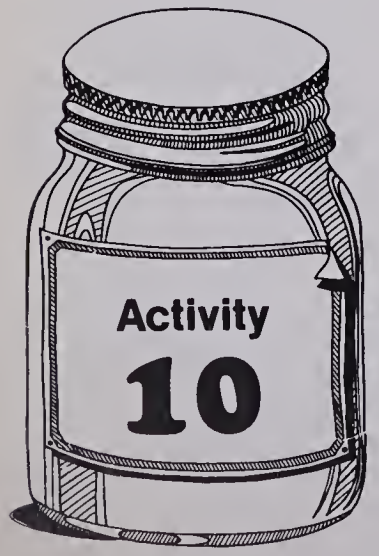
a. warm and moist
b. warm and dry
c. cool and moist
d. cool and dry

✔ 9-6. Do molds seem to need moisture to grow? Explain your answer.

✔ 9-7. Refer to Figure 9-1 to explain whether food can become moldy if it is

a. kept in the refrigerator (5°C).
b. kept in the freezer (−20°C).
c. boiled in a sealed container and then kept at room temperature.
d. heated in a sealed container to 120°C and then stored at room temperature.

Many foods used by hikers, mountain climbers, astronauts, and others are preserved by freeze-drying. In this process, frozen foods are placed in a vacuum chamber. The frozen moisture in the food is drawn out rapidly. The dry solid left behind will not spoil at room temperature. Since there is so little moisture left in the food, food spoilers cannot grow and reproduce in the food.



Baking and Wine-Making

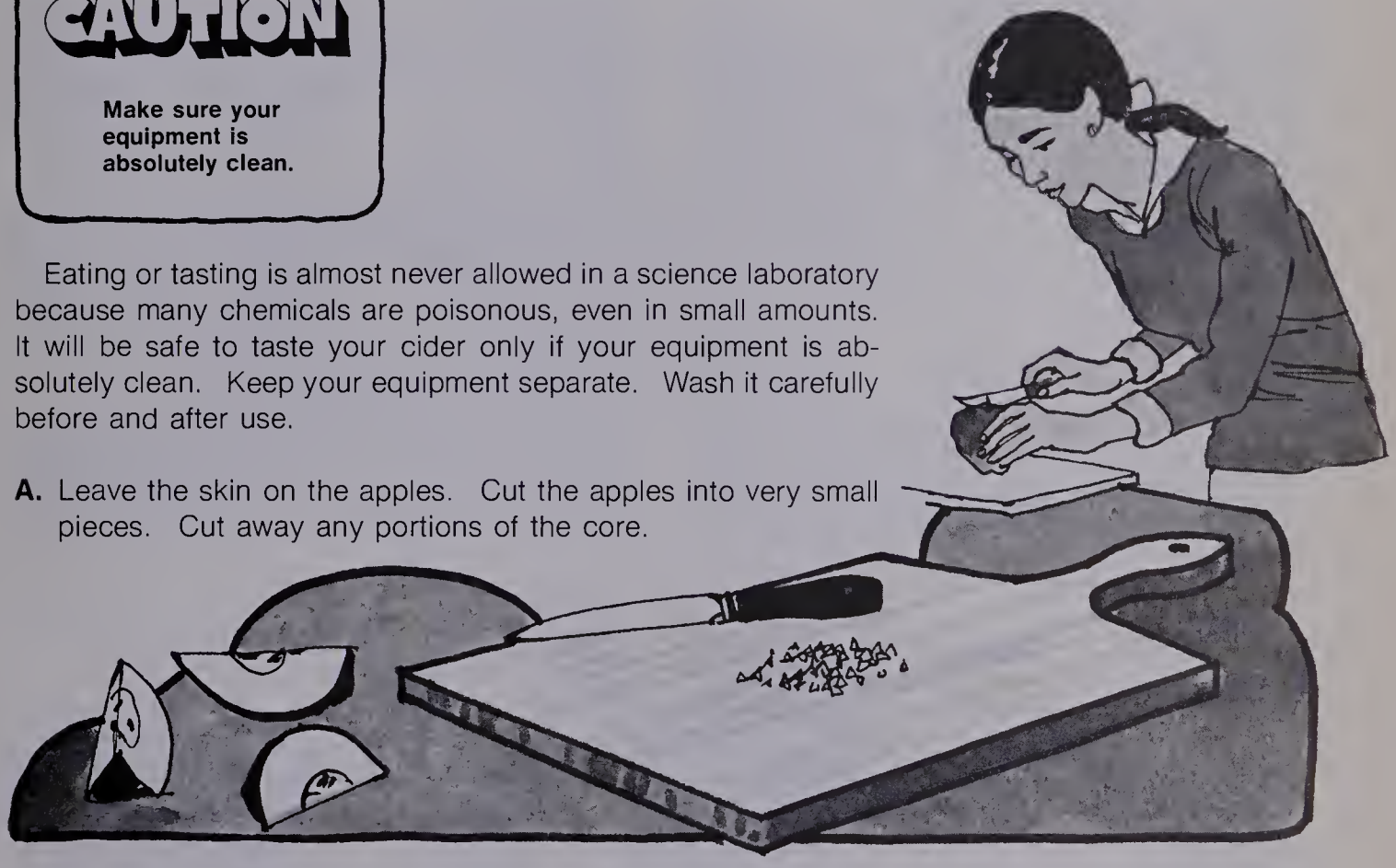
Some microorganisms are used to produce tasty food products. Yeasts, for example, are used to make bread and to change fruit juices into cider or wine. These foods result from *fermentation* caused by yeasts. You can take a closer look at fermentation by making apple cider.

Before you begin, read through the entire recipe. Then collect these items:

kitchen knife
2 ripe apples, bruised perhaps but without decay
mortar and pestle, or rolling pin and chopping board
piece of clean muslin, at least 40 cm x 40 cm
beaker or container, about 400-ml
narrow-mouthed flask or bottle, about 125-ml
rubber stopper, 1-hole, to fit flask or bottle, with glass tubing and rubber tubing inserted.

CAUTION

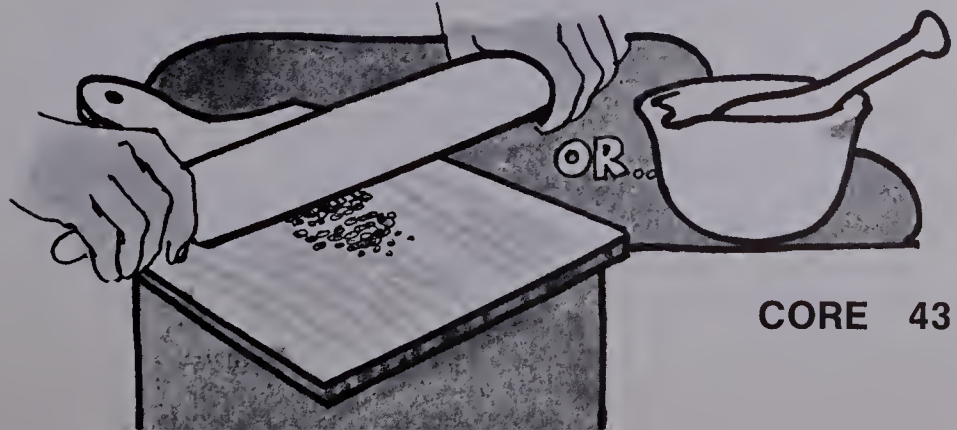
Make sure your equipment is absolutely clean.



Eating or tasting is almost never allowed in a science laboratory because many chemicals are poisonous, even in small amounts. It will be safe to taste your cider only if your equipment is absolutely clean. Keep your equipment separate. Wash it carefully before and after use.

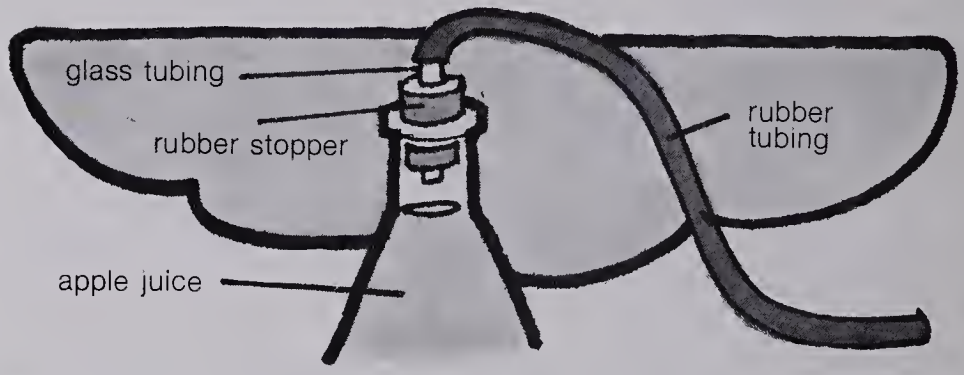
A. Leave the skin on the apples. Cut the apples into very small pieces. Cut away any portions of the core.

B. Crush the pieces of apple with the mortar and pestle or with the rolling pin on the chopping board.

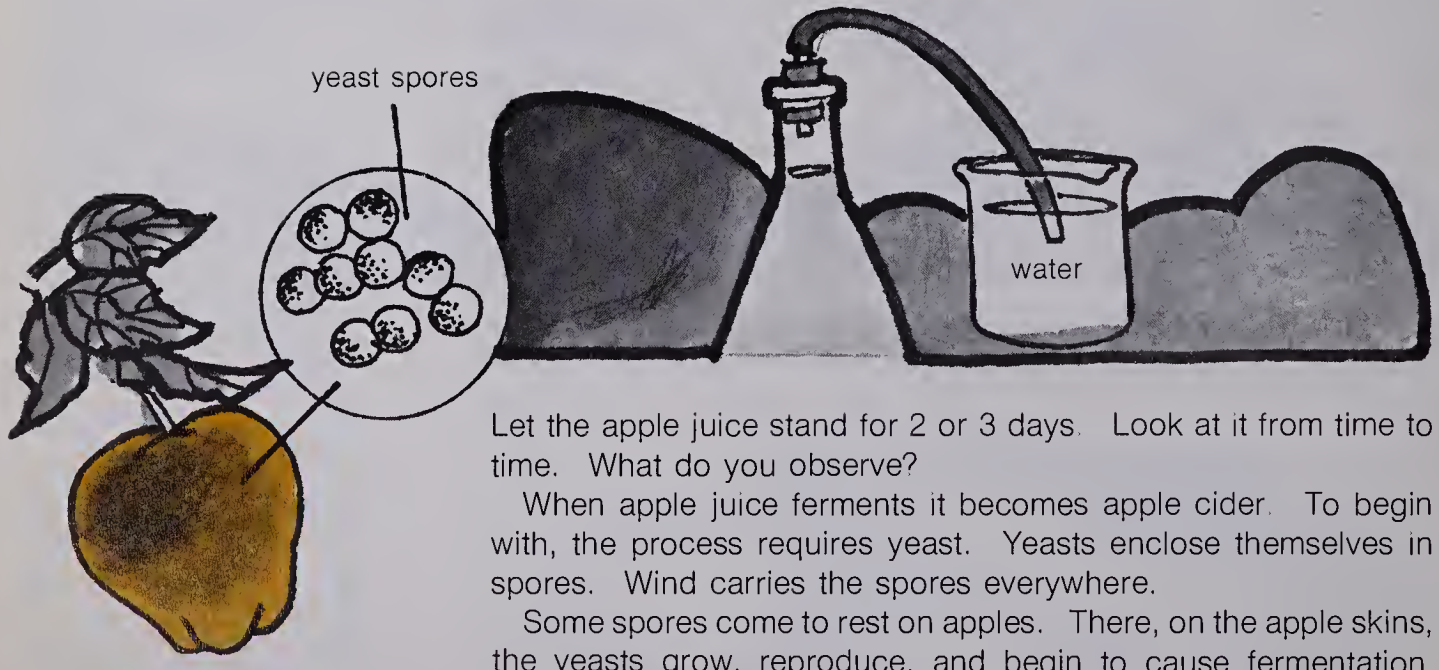


C. Put the crushed apples on the piece of cloth. Hold the cloth like a bag and squeeze the juice into the beaker. Twist the ball of pulp tighter and tighter to remove as much juice as possible.

D. Pour the apple juice into the narrow-mouthed flask. Fill the flask to within 3 or 4 cm of the top. Put the rubber stopper into the flask.



E. Rinse out the beaker, fill it with water, and put the free end of the rubber tubing into the water.



Let the apple juice stand for 2 or 3 days. Look at it from time to time. What do you observe?

When apple juice ferments it becomes apple cider. To begin with, the process requires yeast. Yeasts enclose themselves in spores. Wind carries the spores everywhere.

Some spores come to rest on apples. There, on the apple skins, the yeasts grow, reproduce, and begin to cause fermentation.

So it's the apple skins that are all-important in making cider. This is why you were asked to leave the skins on the apples that you crushed.

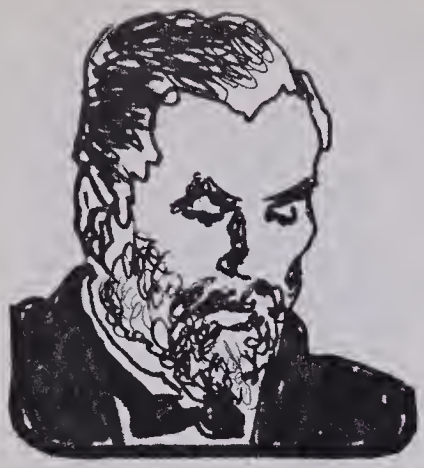
What happens during fermentation of apple juice? Generally the yeasts change the sugar in the apple juice to alcohol and carbon dioxide gas.

There are many kinds of fermentation depending on the kind of sugar used and the kind of yeast present. In making wine, yeasts are used to ferment the sugars in fruit juices. As in other kinds of fermentation, alcohol and carbon dioxide are produced. In winemaking, it is the alcohol that is important.

Other kinds of fermentation are important because of the carbon dioxide gas produced. In making bread, yeasts ferment the sugars in the dough and give off alcohol and carbon dioxide. The carbon dioxide causes the dough to rise and become soft and fluffy as it bakes. The alcohol evaporates from the dough as the bread bakes.

Yeasts are not the only microorganisms that cause fermentation. Bacteria and other microorganisms do too. They are also involved, through fermentation, in the making of cheese, buttermilk, chocolate, sauerkraut, and dill pickles. Some microorganisms give off carbon dioxide and alcohol during fermentation; some produce acids. The products of fermentation depend on the kind of microorganism that is doing the fermenting.

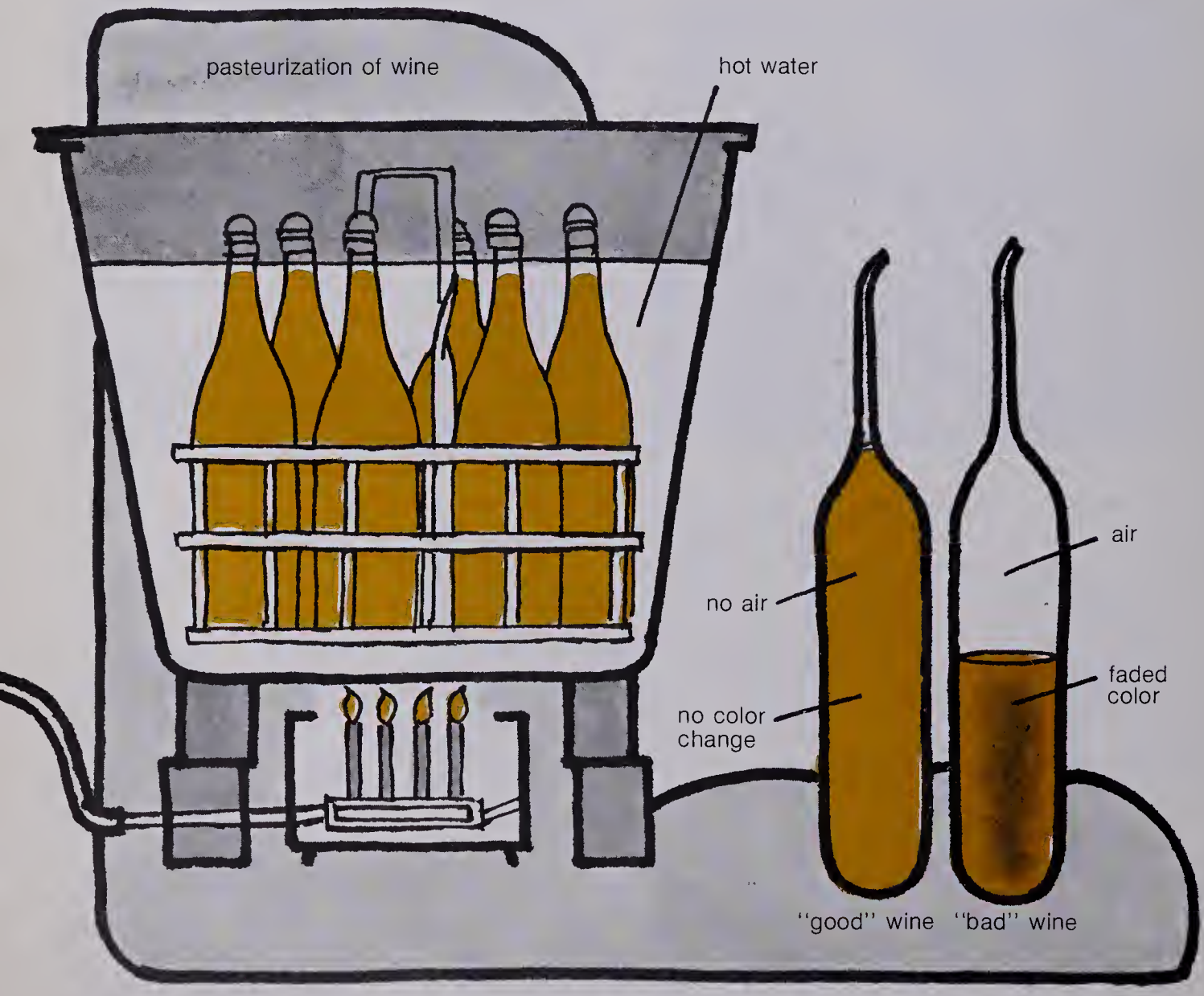
When you use fermentation to make a food product, you must be sure that the right microorganisms are doing the work. In the 1800s, French winemakers were facing a serious problem: Some of their grape juice was turning into an acid-tasting substance like vinegar, instead of into wine.



Louis Pasteur, 1822–1895
French chemist and biologist

The winemakers asked for the help of Louis Pasteur. At that time, Pasteur was doing some research on microbes, his term for bacteria, molds, and yeast. Pasteur found that certain bacteria in the air were getting into the grape juice. They were causing fermentation all right, but not the right kind! Instead of changing the sugar in the grape juice to alcohol, the bacteria were changing it to an acid.

Pasteur suggested that the grape juice be heated. This would kill the unwanted bacteria without harming the flavor of the juice. He "pasteurized" the grape juice by heating it to 63°C for 30 minutes.



✔ 10-1. How do you think milk is pasteurized?

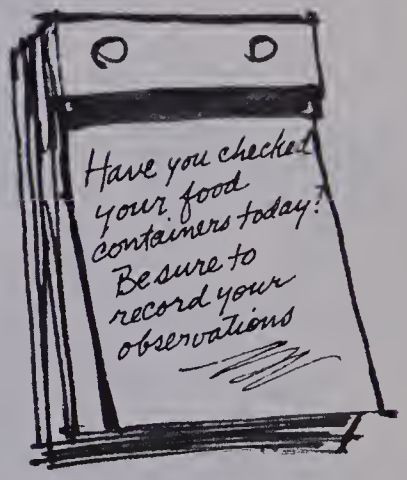
Bacteria can invade your apple juice, too. Then the juice might become vinegar, or acetic acid, instead of cider. To try to prevent this, your setup doesn't allow bacteria in the air to come in contact with the apple juice. That's why the flask is stoppered and the end of the rubber tubing is under water.

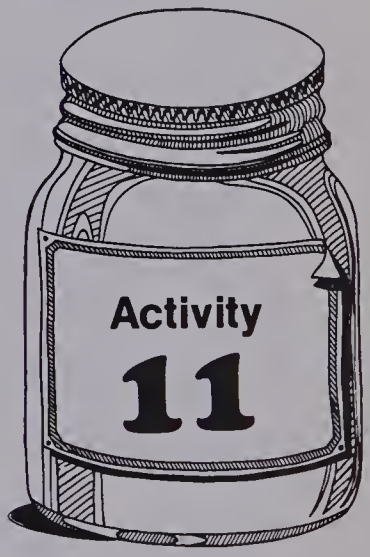
✔ 10-2. Why didn't you use a stopper without a hole and close the flask up tight? (Hint: What's the other product of fermentation besides the alcohol or acid?)

✔ 10-3. Take a look at the apple juice. Do you see evidence that a gas is being produced? If so, what evidence?

✔ 10-4. Check your "cider flask" after 2 or 3 days. Taste the cider. What does it taste like, cider or vinegar? (If the cider is moldy, you may not want to taste it.) If it tastes like vinegar, explain what must have happened.

★ **10-5. What microorganisms are primarily responsible for making breads and wines?**



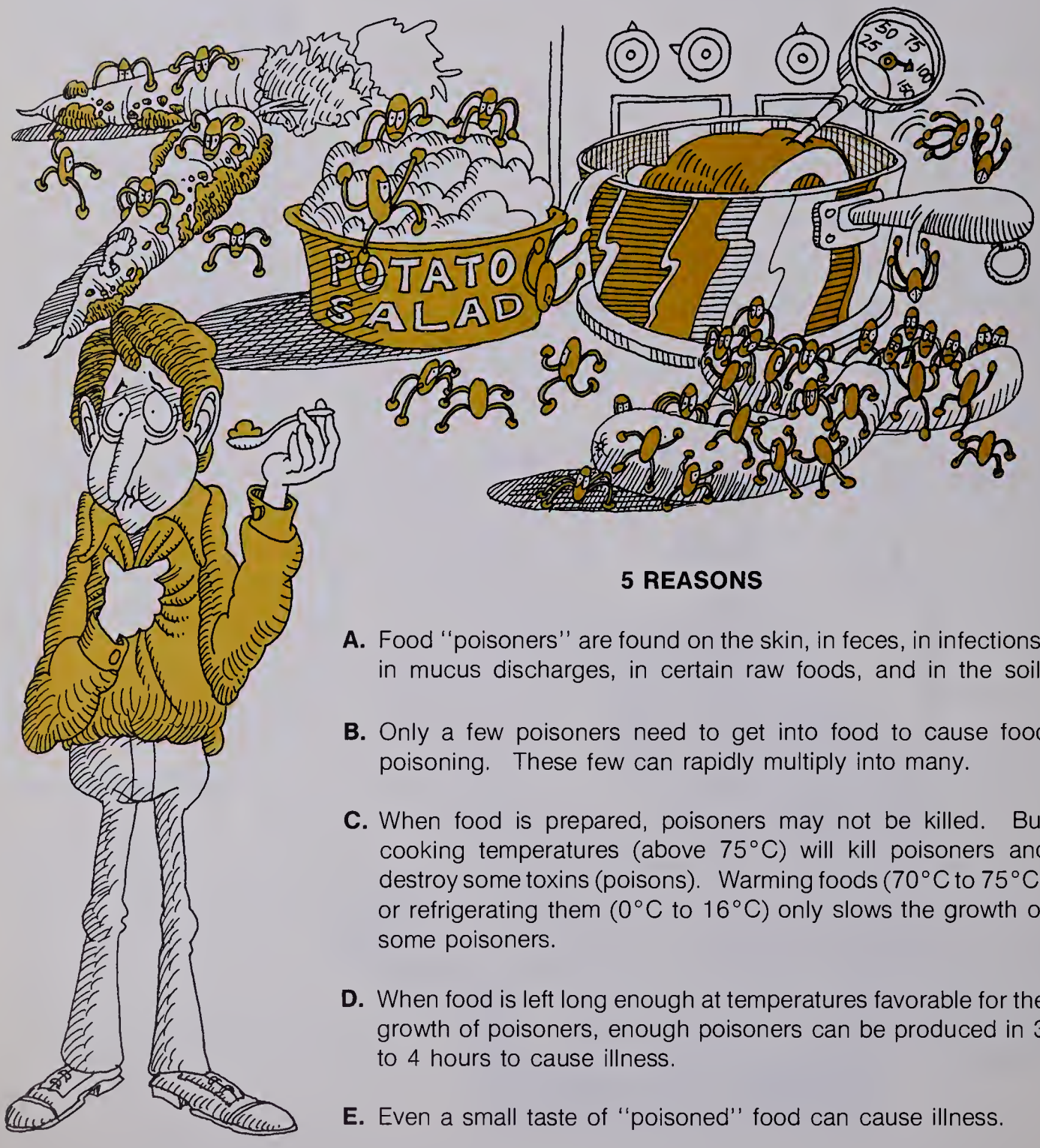


Keep Your Hands Off!

Many restaurants post a list of rules for handling foods. Similar rules are important to remember when preparing foods at home.

It's easier to follow a rule when you know a reason for it. So here are 16 food-handling rules and five reasons for following them. Each reason focuses on the "poisoner," or harmful micro-organism, that causes food poisoning. The poisoners may be bacteria, yeasts, or molds.

✔ 11-1. Match a reason to each rule.



5 REASONS

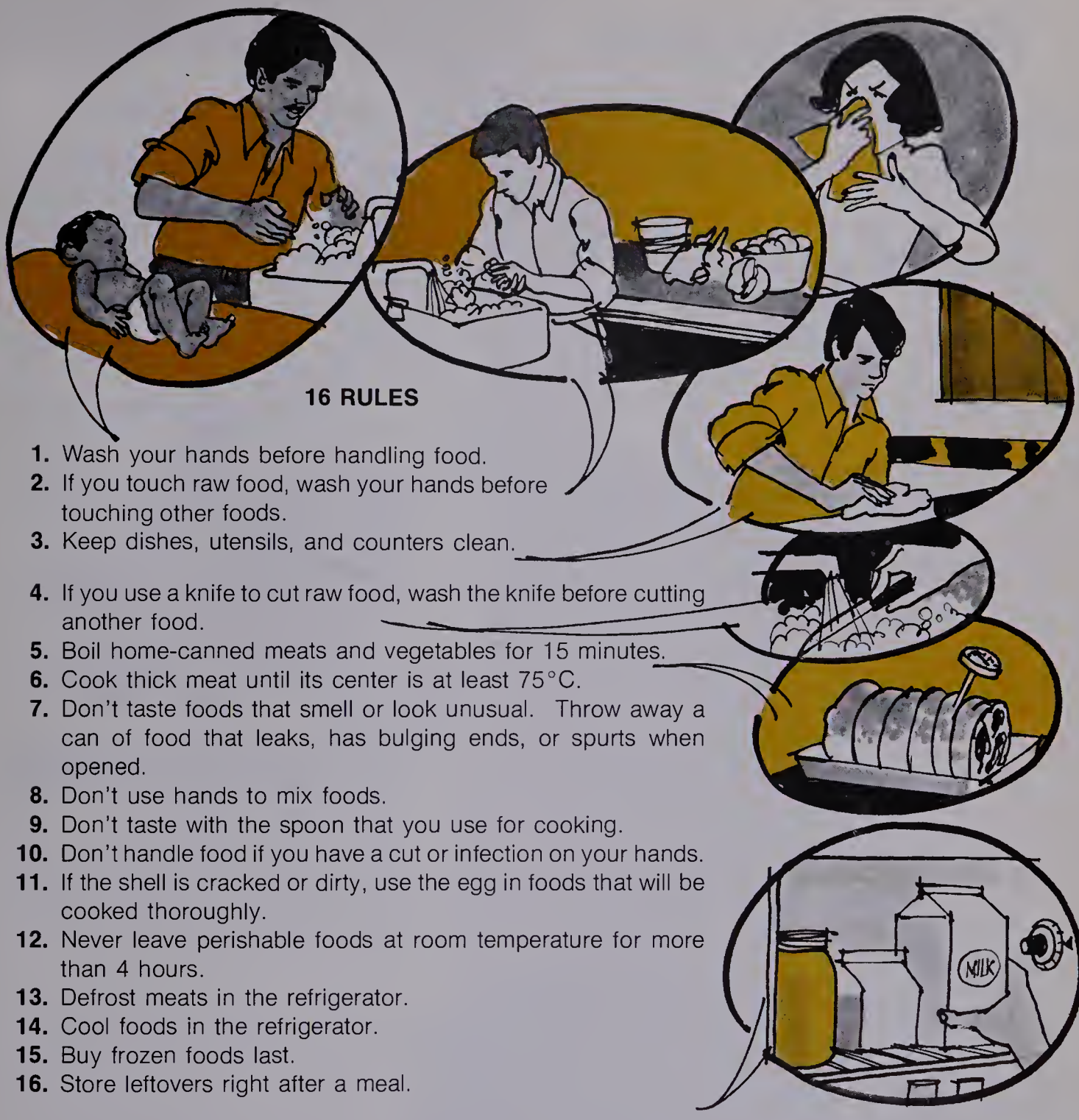
A. Food "poisoners" are found on the skin, in feces, in infections, in mucus discharges, in certain raw foods, and in the soil.

B. Only a few poisoners need to get into food to cause food poisoning. These few can rapidly multiply into many.

C. When food is prepared, poisoners may not be killed. But cooking temperatures (above 75°C) will kill poisoners and destroy some toxins (poisons). Warming foods (70°C to 75°C) or refrigerating them (0°C to 16°C) only slows the growth of some poisoners.

D. When food is left long enough at temperatures favorable for the growth of poisoners, enough poisoners can be produced in 3 to 4 hours to cause illness.

E. Even a small taste of "poisoned" food can cause illness.



16 RULES

1. Wash your hands before handling food.
2. If you touch raw food, wash your hands before touching other foods.
3. Keep dishes, utensils, and counters clean.
4. If you use a knife to cut raw food, wash the knife before cutting another food.
5. Boil home-canned meats and vegetables for 15 minutes.
6. Cook thick meat until its center is at least 75°C.
7. Don't taste foods that smell or look unusual. Throw away a can of food that leaks, has bulging ends, or spurts when opened.
8. Don't use hands to mix foods.
9. Don't taste with the spoon that you use for cooking.
10. Don't handle food if you have a cut or infection on your hands.
11. If the shell is cracked or dirty, use the egg in foods that will be cooked thoroughly.
12. Never leave perishable foods at room temperature for more than 4 hours.
13. Defrost meats in the refrigerator.
14. Cool foods in the refrigerator.
15. Buy frozen foods last.
16. Store leftovers right after a meal.

✔ 11-2. Suppose some turkey stuffing is left on the table for 6 hours. That night, you warm up some turkey stuffing for a snack. Predict what might happen.

Have you checked your food containers today? Be sure to record your observations.

★ **11-3. What are four ways that food gets "poisoned"?**

advanced

Activity 12 Planning

If you plan to do Activity 15, you will need to do Activity 2 at least 3 or 4 days before you start.

Activity 13 Page 51

Objective 14: Identify substances involved in fermentation and its end products. Describe the process of fermentation.

Sample Question: What are three products of fermentation?

Activity 14 Page 56

Objective 15: Describe the appearance of bacteria and the growth patterns of their colonies.

Sample Question: What are three shapes of bacteria?

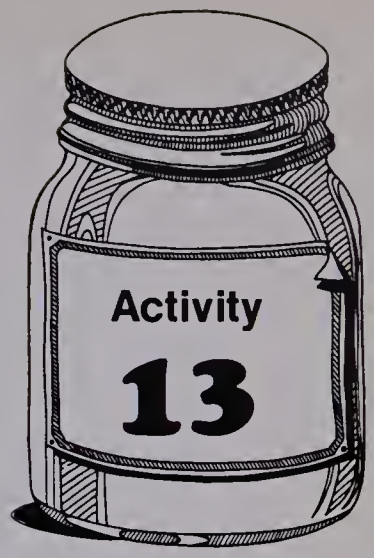
Activity 15 Page 62

Objective 16: Explain why a certain microorganism will grow on one food but not another.

Sample Question: One kind of mold will grow on oranges; another kind will not. The two kinds of mold probably differ in their ___?___ .

Answers

14. *alcohol, carbon dioxide, and ATP*
15. *spiral, rod, sphere*
16. *enzymes*

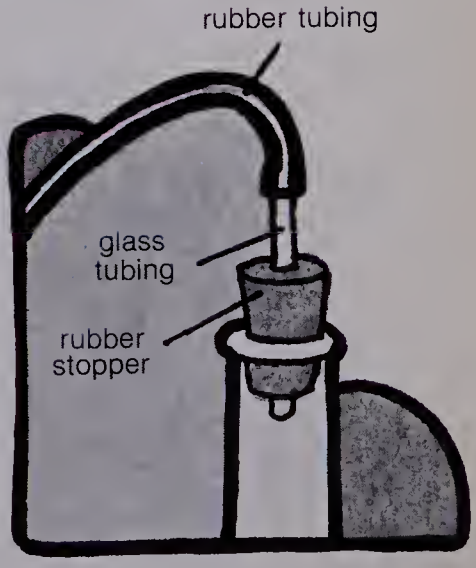


Fermenting

Yeasts are used in the making of bread, wine, and cider. These microorganisms also cause foods to spoil. From the viewpoint of people, these are both helpful and harmful roles. From the viewpoint of yeasts, these roles are very much the same: They all provide the yeast with sugars for food. For unlike green plants, yeasts can't make their own sugars through photosynthesis. Yeasts grow in fruit juices, breads, and other foods where they obtain sugars.

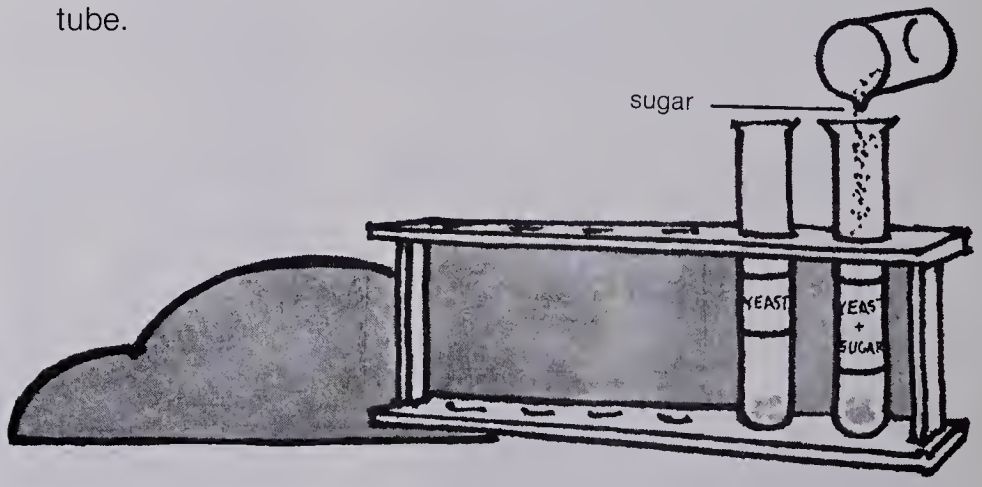
The process by which yeasts use these sugars is called *fermentation.* Here is a way you can examine this process. You'll use the store-bought yeast that is used in making bread. Read through the entire investigation. Then collect these items:

- test-tube rack
- 4 test tubes, each about 15 cm in length
- grease pencil
- 1 g (or 1 ml) sugar
- 2 rubber stoppers, 1-hole, with glass tubing and rubber tubing attached
- graduated cylinder
- warm (35°C) tap water
- phenol red
- active dry yeast, 1 package
- beaker, 250-ml
- stirring rod

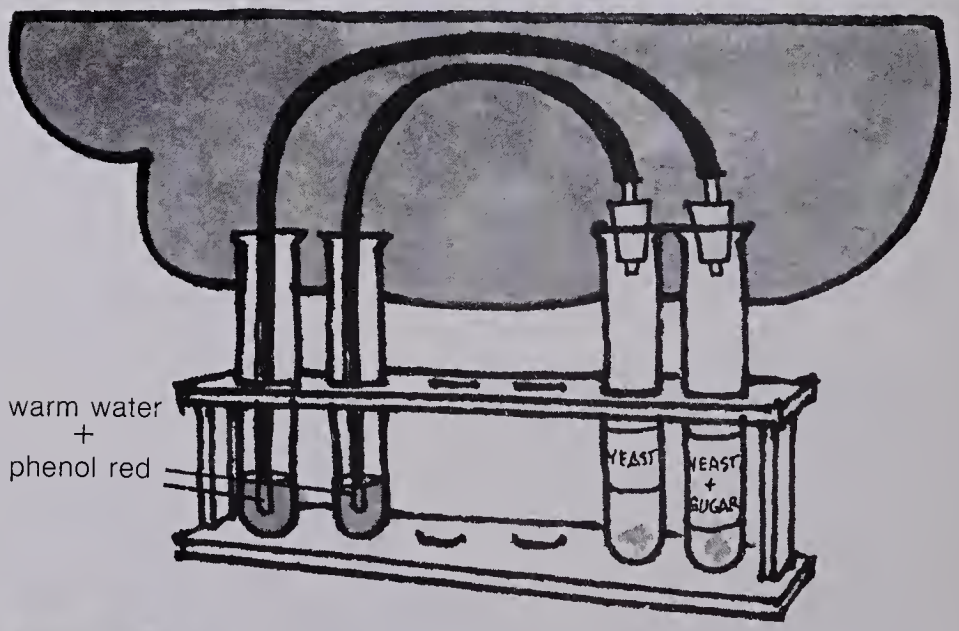


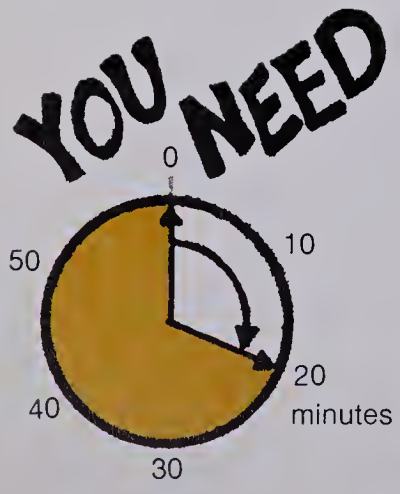
Before you begin, you need to know that phenol red is a dye. It turns from red to yellow when it comes in contact with carbon dioxide.

A. Use the graduated cylinder to measure the small amount of sugar, about 1 ml. Set two test tubes in the tube rack. Write *yeast* on one. Write *yeast + sugar* on the other and put the sugar in it. Put a stopper with tubing attached on each test tube.



B. In each of the other two test tubes, put 5 ml of warm water and 2 drops of phenol red. Position the 4 test tubes with the tubing running between them as shown. Notice that each tube containing yeast is connected to a tube containing phenol red.



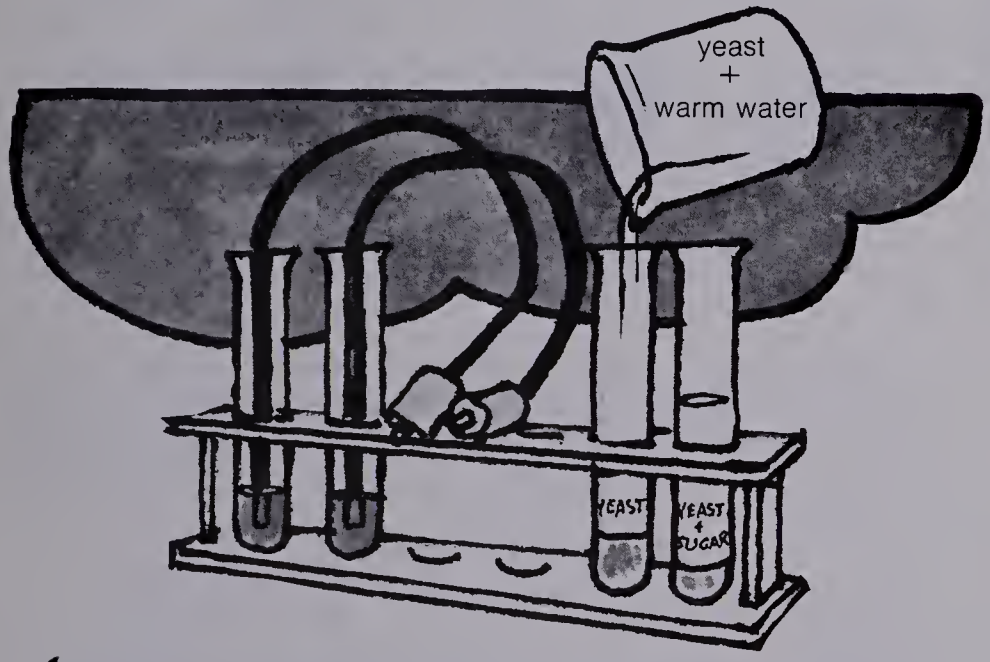


IMPORTANT: Now you are ready to add the yeast. You'll need at least 20 minutes to do this and then make observations. Do not go to Step C unless you have enough time.

C. In a beaker, mix 1 ml of yeast with 20 ml of warm (35°C) water.

D. Put 10 ml of the yeast-water mixture into each of the two test tubes labeled *yeast*. Return the stopper to each test tube.

Check the appearance of the phenol red every 2 or 3 minutes. For a faster reaction, put the test tubes in a beaker of warm water. The reaction will be complete in about 15 minutes.



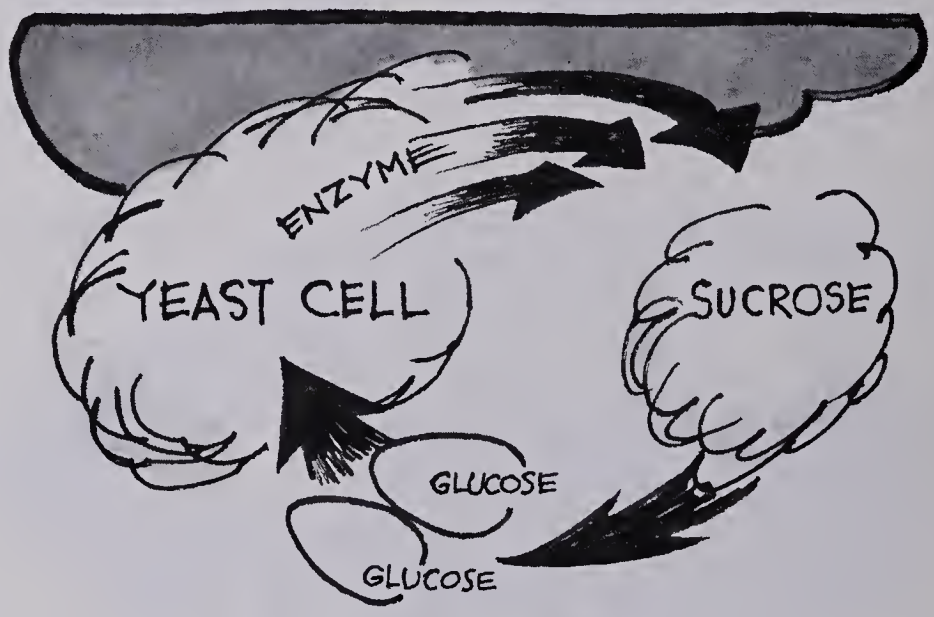
✔ 13-1. What happened to the phenol red in the setup labeled *yeast?* Describe and explain any change. (Remember that the dye turns from red to yellow in the presence of carbon dioxide.)

✔ 13-2. What happened to the phenol red in the setup labeled *yeast + sugar?* Describe and explain any change.

★ **13-3. During fermentation what is necessary to produce carbon dioxide?**

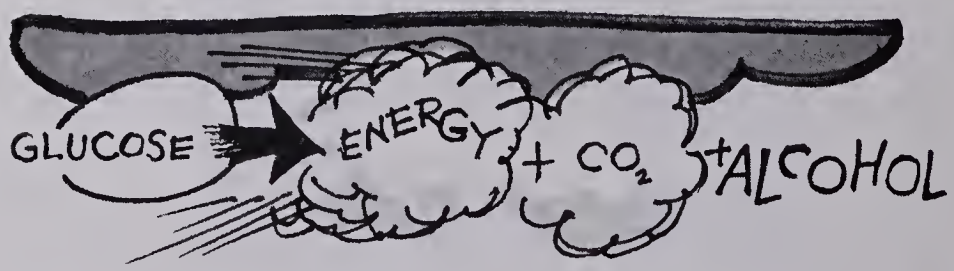
During fermentation, yeasts change sugars into carbon dioxide and alcohol. More important, during fermentation yeasts get energy for growth and reproduction. How does this happen?

To answer, you must know what happens inside a test tube containing yeast and table sugar. First the yeast cells release an enzyme, a substance that causes a chemical change. The enzyme causes a change in the sugar, or sucrose. The enzyme breaks each sucrose molecule into simpler sugars, called *glucose molecules.* Then the yeast cells absorb the glucose molecules through their cell membranes.



Enzymes inside the yeast cell digest, or break down, the glucose molecules. When this happens the energy stored in the glucose molecules is released. The yeast can use the energy for growth and reproduction. The final products of fermentation are carbon dioxide and alcohol.

Fermentation can be summarized like this:

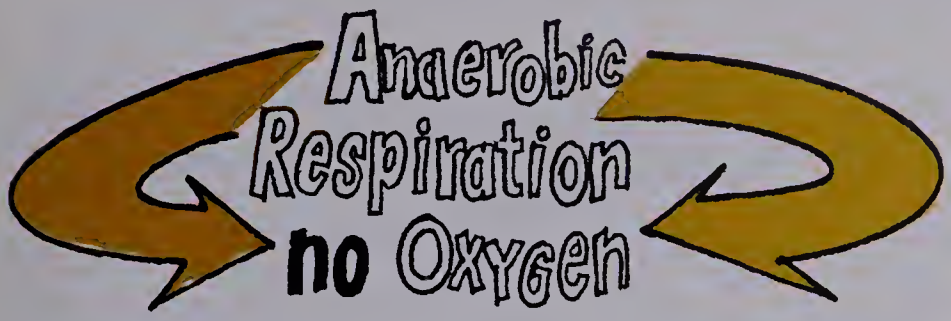


★ **13-4. What product of the fermentation of sugar by yeast is important in getting bread to rise?**

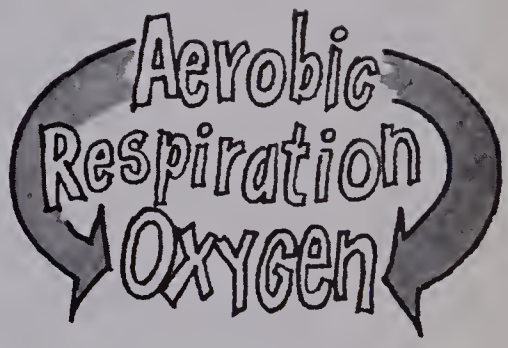
★ **13-5. What is the function of enzymes in the fermentation process?**

Another term for fermentation is *anaerobic* [an-a-RO-bik] *respiration*. Anaerobic means that the process does not require oxygen.

In your investigation of fermentation, very little oxygen was available to the yeast. The end of the tubing that stretched from the yeast's test tube was under water. No oxygen from the air could get to the yeast cells.

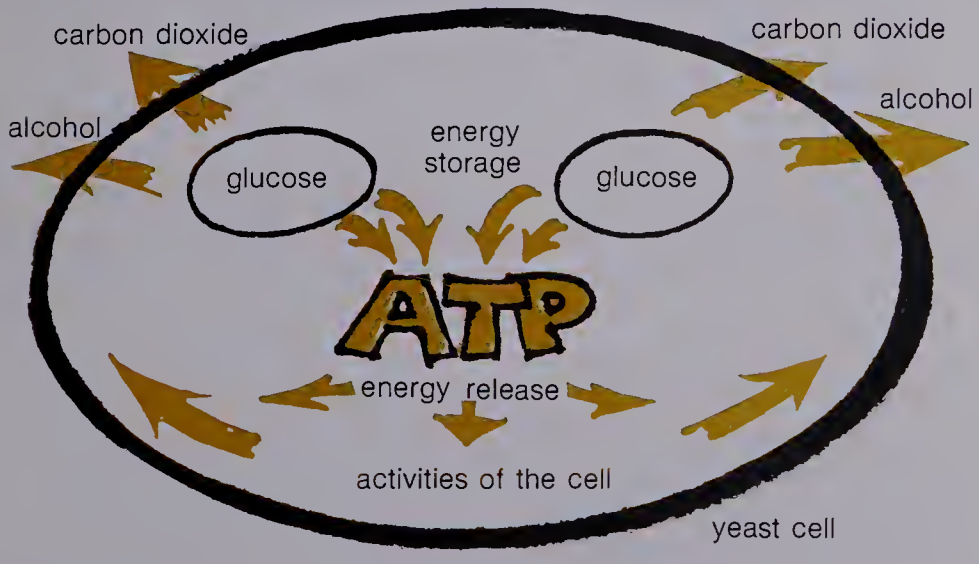


Aerobic [a-RO-bik] respiration *does* require oxygen. Aerobic respiration releases much more energy than anaerobic respiration. People get most of their energy from aerobic respiration.

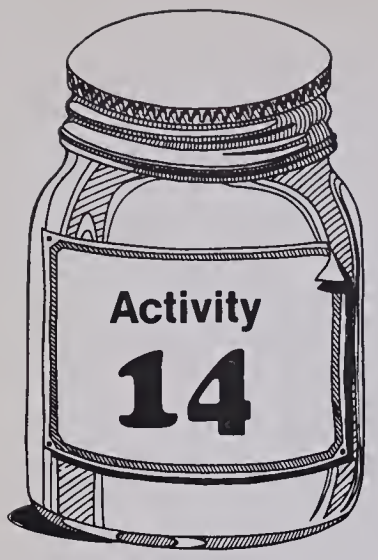


What happens to energy released from the glucose molecule? In the yeast cells, the glucose molecule is taken apart, but not all at once. Energy is released from the glucose molecule in small steps. This energy is then stored in a special molecule called adenosine triphosphate [a-DEN-a-seen try-FOS-fate], or ATP. The ATP molecule can also give up the stored energy whenever the yeast cell needs it.

★ **13-6. What product of fermentation is important to the growth and reproduction of the yeast cell?**



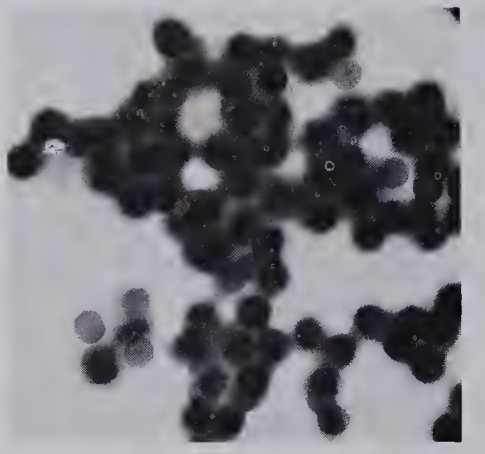
The entire process of fermentation is a complicated one. It is a series of chemical reactions that go on inside the yeast cell.



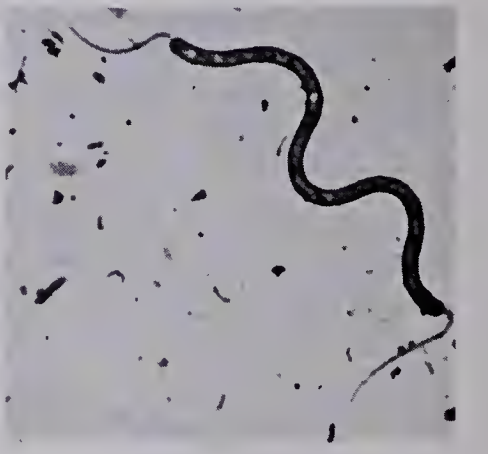
Growing Bacteria

There are thousands of different kinds of bacteria. Figure 14-1 shows what some of these look like when viewed through a very powerful microscope. The illustration also shows that bacteria are often named for their shapes.

rod-shaped, or *bacilli*



sphere-shaped, or *cocci*



spiral-shaped, or *spirilla*

Figure 14-1

★ **14-1. What shape are *staphlococci* bacteria?** (Refer to Figure 14-1 to answer.)

You can't see a single bacterium. Bacteria are so small that your own school microscope can only show them as tiny dots.

Bacteria usually grow clumped together. When enough of them grow in one spot, they're called a *colony.* The colony *is* visible to your eye. One small colony may contain as many bacteria as there are people in a large city.

The colonies of different kinds of bacteria look different. The colonies have different shapes, textures, colors, and thicknesses.

Each colony starts from one single bacterium. As a bacterium grows it divides into two bacteria. Then the two new bacteria each divide; now there are four. Each division happens rapidly, sometimes as often as every 20 minutes. Several billion bacteria can result in less than 1 day.

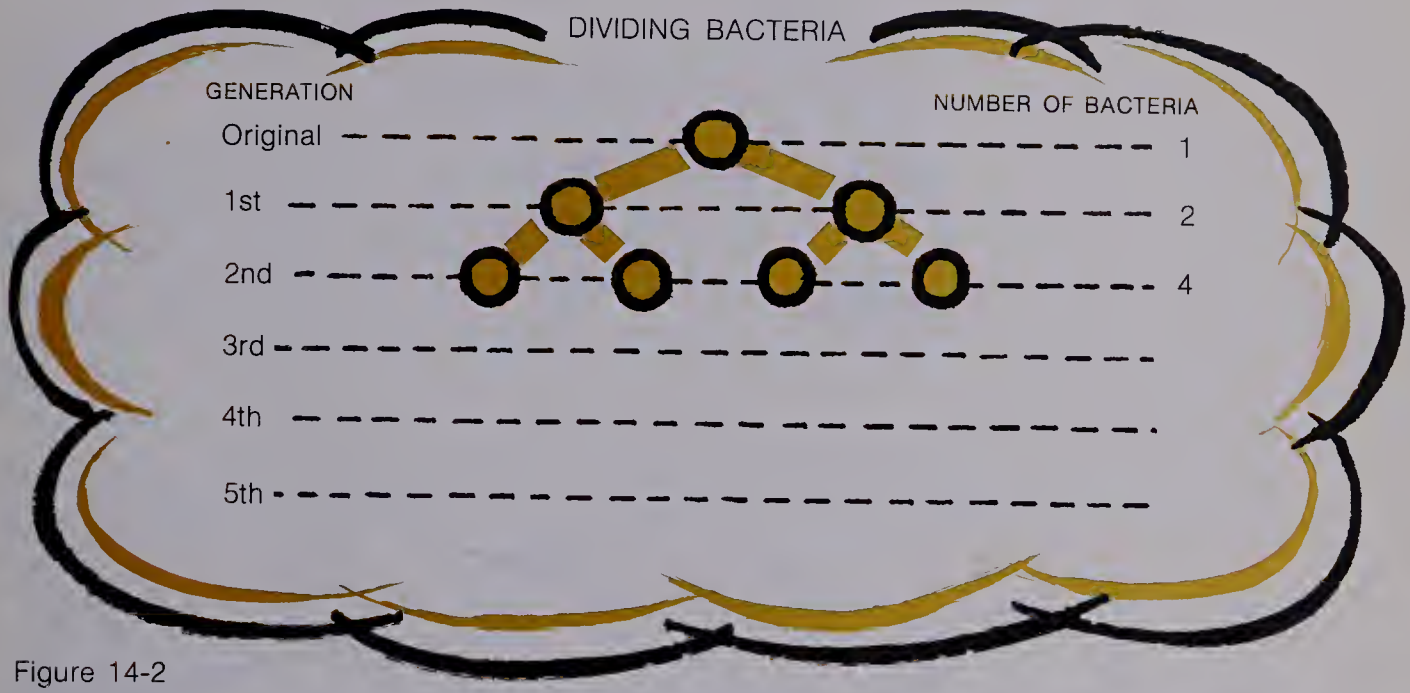


Figure 14-2

✔ 14-2. In your notebook, complete the chart in Figure 14-2.

✔ 14-3. How much larger is each generation than the previous one?

✔ 14-4. How many bacteria are there in the 6th generation?

BACTERIA NEED

1. moisture
2. nourishment
3. heat

You may not realize that you have seen bacterial colonies. Probably you have seen spoiled meat coated with a lightly colored slime. If so, you have seen a colony. Bacterial colonies grow where the conditions are favorable. They don't grow well on fruit because it is too acidic. And they don't thrive on bread because it is usually too dry. Bacteria need moisture, nourishment, and warm temperatures to grow and reproduce.

Deliberately growing bacteria is called culturing bacteria. Colonies are grown that are large enough to see.

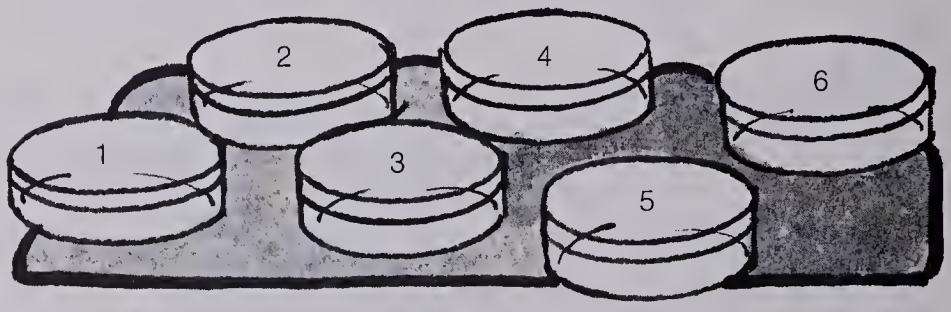
Colonies can be grown in a special broth. This broth, or soup, contains nutrients—sugars, minerals, and vitamins—that the bacteria use as food. Agar, a jelly-like material made from seaweed, is also used for culturing bacteria. The agar is sterilized and nutrients are added.

You can use agar to culture some of the bacteria that are on your hands. And you can find out how washing your hands in various ways affects the bacteria. You will need the following items:

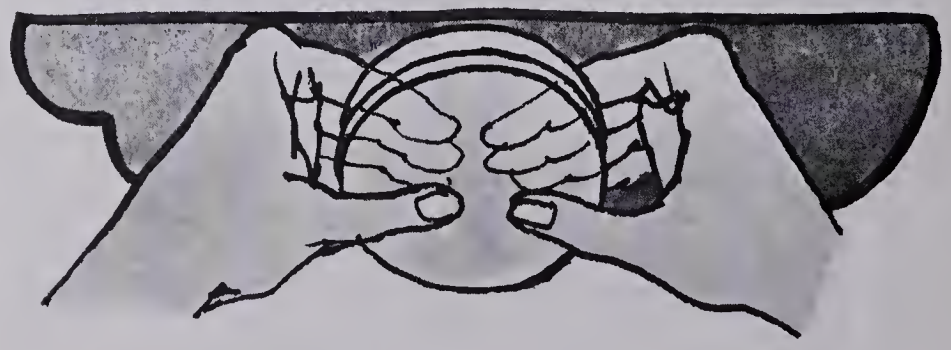
6 sterilized petri dishes containing agar
grease pencil
soap and water
antiseptic: a weak chlorine solution

IMPORTANT: Before you begin, read through all the directions. The petri dishes and agar in them are sterilized. Avoid exposing them to any bacteria—in the air, in your breath, etc. Therefore work quickly and carefully on Steps D, F, G, H, I.

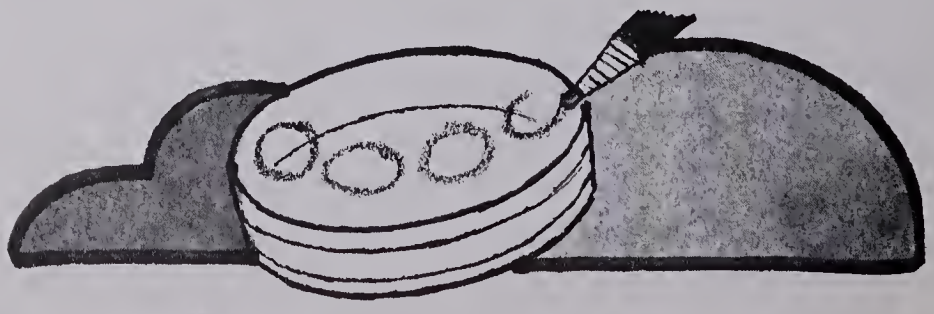
A. Do not open the dishes. Number the petri dishes *1* through *6*.



B. Without opening the dishes, turn each one bottom up.

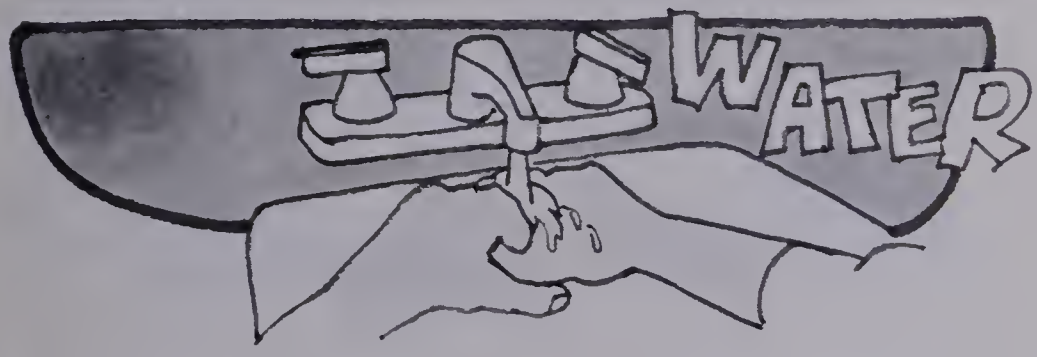


C. Draw four circles on the bottom of each dish.

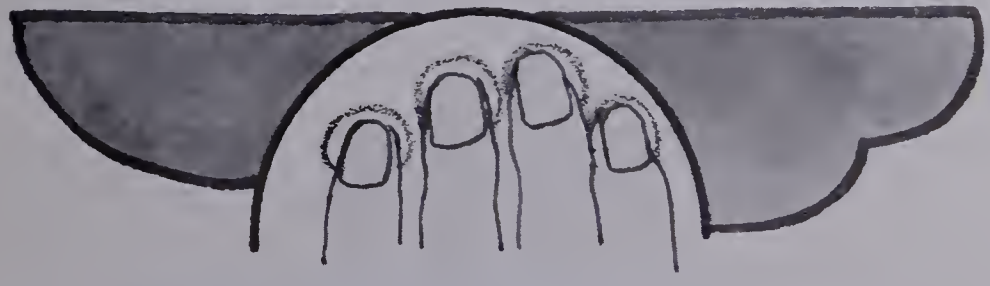


D. Lift one side of the lid for Dish 1. Don't breathe on the dish; keep your face away from it. Quickly and carefully place the fingertips of your other hand just under the lid onto the agar, one finger over each circle, and press lightly. Don't push down hard on the agar. Quickly replace the cover.

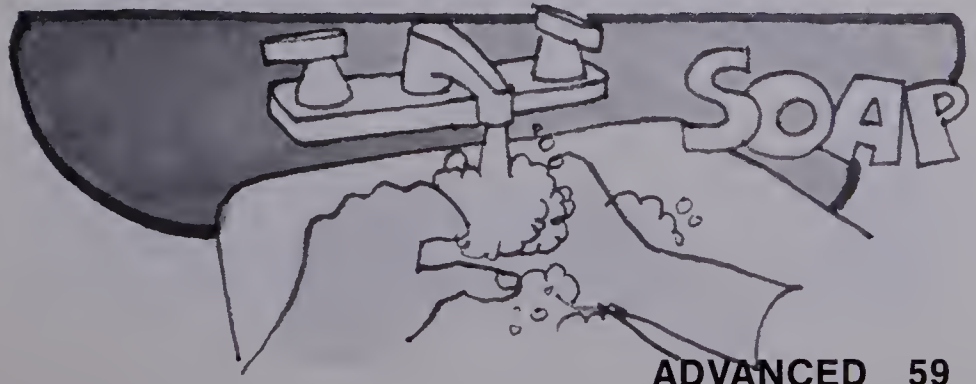
E. Rinse your hands under cold water for 20 seconds. Shake the excess water off, but don't touch *anything*.



F. Repeat Step D with Dish 2.



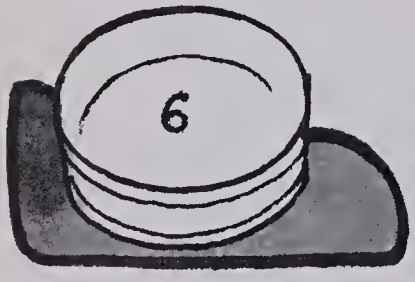
G. Now wash your hands with soap and water for 20 seconds, rinse, shake quickly, and repeat Step D with Dish 3.



H. Repeat Step G with Dish 4.

I. Wash your hands in the weak chlorine solution for 20 seconds. Rinse your hands and shake them quickly. Repeat Step D with Dish 5.

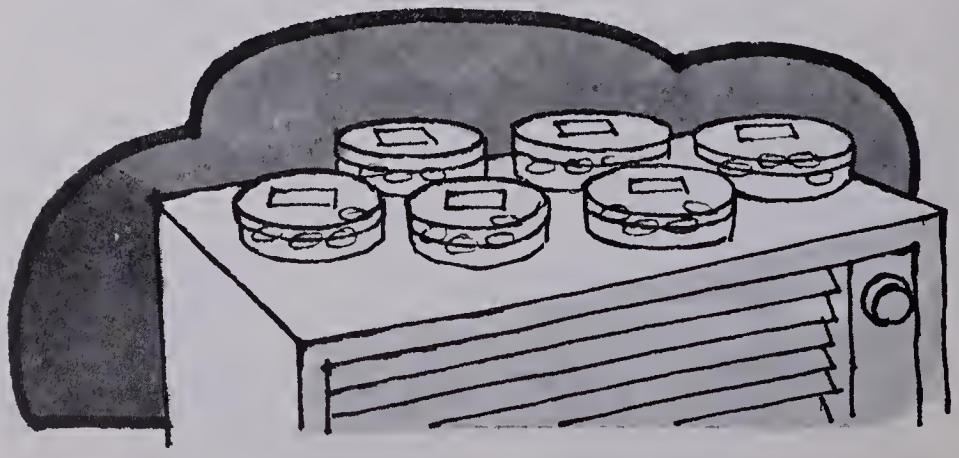
DON'T TOUCH.



J. Do not open Dish 6. It is the control dish.

IMPORTANT: Now all your petri dishes are prepared and closed to the air. Don't even open them later when you make observations.

K. Place all 6 petri dishes in a warm place out of direct sunlight. Put them where they will not be disturbed.



CULTURING BACTERIA FROM YOUR HANDS

AGAR IN PETRI DISH TOUCHED BY—	OBSERVATIONS	
	After 24 Hours	After 48 Hours
1. Hands unrinsed and unwashed.		
2. Hands rinsed in cold water for 20 seconds.		
3. Hands washed with soap and water for 20 seconds.		
4. Hands washed with soap and water for another 20 seconds.		
5. Hands washed in antiseptic solution for 20 seconds.		
6. Agar not touched.		

Figure 14-3

✔ 14-5. Make a chart like Figure 14-3. Record your observations after 24 hours and after 48 hours.

✔ 14-6. Where did the bacteria get moisture and nourishment while growing in the petri dishes?

✔ 14-7. At what temperatures did you grow the bacteria?

✔ 14-8. Are the smallest spots on the agar individual bacteria or colonies of bacteria?

✔ 14-9. Which dish had the fewest colonies of bacteria? Which dish had the most? Why do you think this happened?

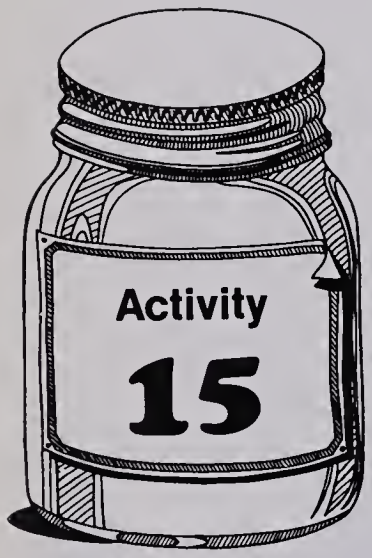
✔ 14-10. What is the purpose of Dish 6, the control dish?

✔ 14-11. Do you think that more than one kind of bacteria are growing in the dishes? What evidence do you have?

✔ 14-12. Is there a pattern to the number of bacteria growing in the dishes? If so, describe the pattern.

CAUTION

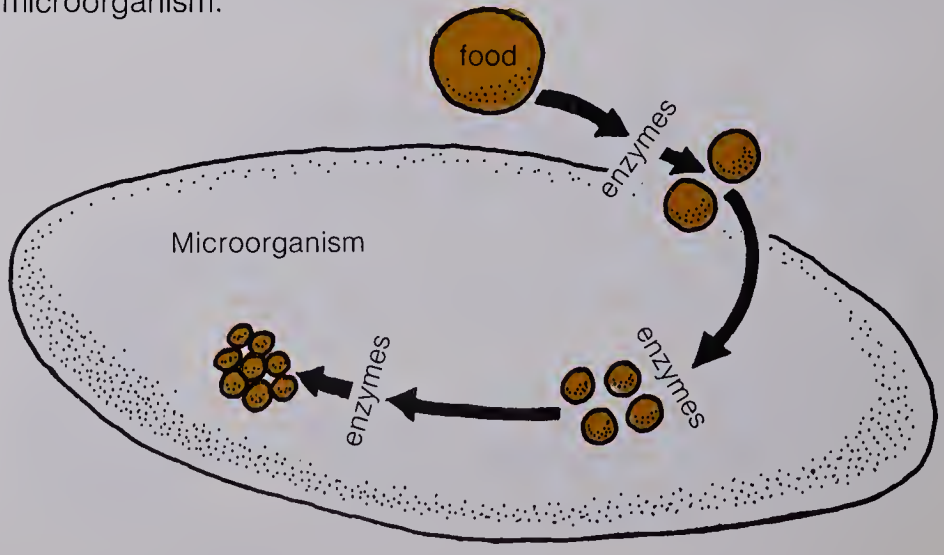
Your teacher will give you directions for disposing of the cultures.



The Enzyme Is Essential

In Activity 2, you put different kinds of foods in containers and allowed microorganisms to grow on the food. You probably found that different food spoilers grow on different foods. Why does one food spoiler thrive on a certain food and not on another? To answer this question, you must know what happens when a microorganism begins to grow on a certain food.

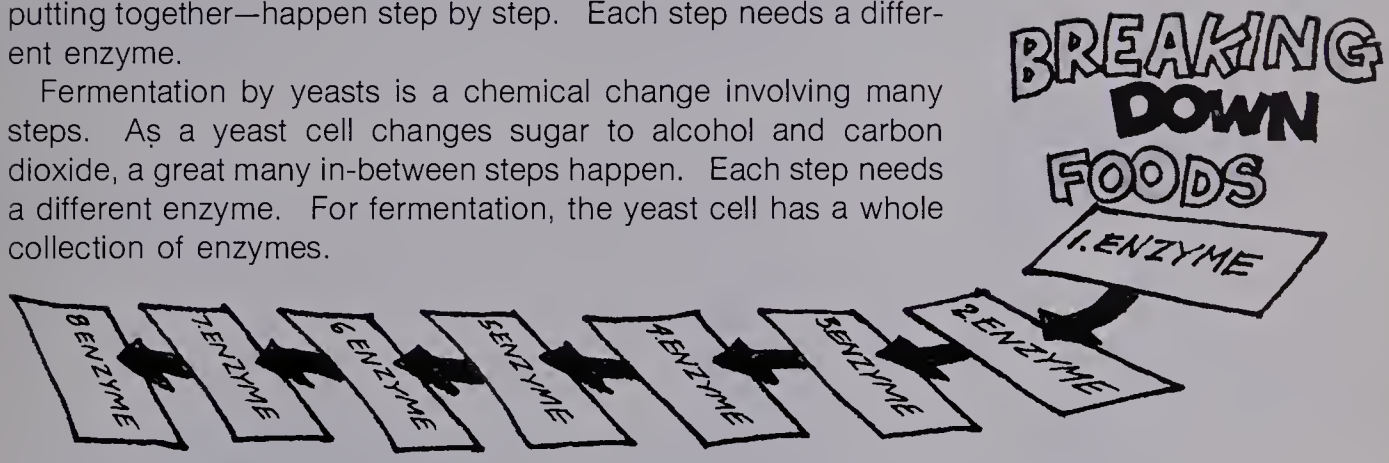
The microorganism secretes certain enzymes, substances that cause chemical changes. These enzymes break down certain food molecules into smaller ones. Then these small molecules pass through the cell membrane and on to the inside of the microorganism.



Once inside the cell, other enzymes break down these small molecules into still simpler ones. And other enzymes put the simple molecules together in new combinations to make materials needed by the cell.

All of these chemical changes—the breaking down and the putting together—happen step by step. Each step needs a different enzyme.

Fermentation by yeasts is a chemical change involving many steps. As a yeast cell changes sugar to alcohol and carbon dioxide, a great many in-between steps happen. Each step needs a different enzyme. For fermentation, the yeast cell has a whole collection of enzymes.



Now what about the question, Why does one food spoiler thrive on a certain food and not on another? Or, why do yeast cells grow on the skins of apples and other fruits, but not on some other foods? Because the yeast cells have the enzymes that can break down the sugar in the fruits into simpler compounds.

★ 15-1. What determines the kind of microorganism that can grow on a particular food?

You can do an experiment to find out what foods one food spoiler can live on. Pick one of the food spoilers that you grew in Activity 2. You might select a mold as your experimental microorganism. You'll try to grow your microorganism on a variety of foods. Figure 15-1 shows you how to transfer the original microorganism to new containers.

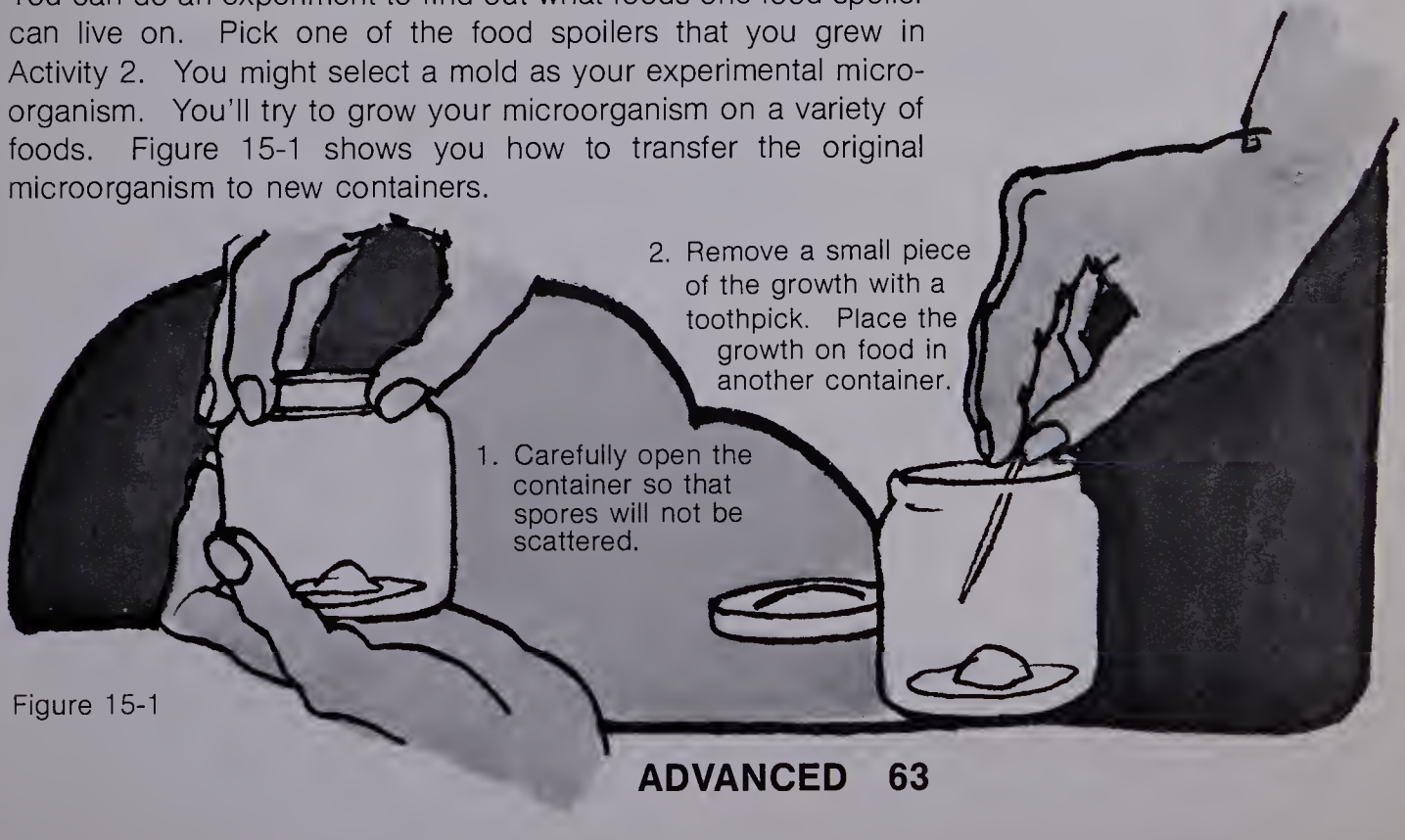


Figure 15-1

EXPERIMENTING

Now plan your experiment. What kind of food spoiler—bacteria, yeast, or mold—will you use? What foods will you try to grow the spoiler on? What containers will you use for your cultures? Where will you place the food containers after you have prepared them? Should the place be sunny or shady, warm or cool, etc?

You'll especially need to consider these questions:

1. Should all containers be kept at the same temperature?

2. Should there be a special control container with no micro-organisms added to it?

Your Problem

✔ 15-2. Describe your experimental problem. This is the question that you are investigating. Include the kind of food spoiler and the kinds of food you are using.

Your Procedures

✔ 15-3. List all your experimental procedures. Include a description of the place(s) where you will store the food containers. Also describe the environment—temperature, amount of light, etc.—where you store the containers.

After you set up your experiment, observe your food containers daily. Record your observations. After several days, or when growth is noted in several containers, answer Questions 15-4 through 15-7.

✔ 15-4. In which containers is food spoilage occurring?

✔ 15-5. What do the spoiled foods have in common? How are the nonspoiled foods different from the spoiled ones?

✔ 15-6. What happened in the control container(s)?

✔ 15-7. Whether or not a certain food spoiler grows on a certain food depends on the spoiler's enzymes. Explain this idea by using the results of your experiment.

excursion

Activity 16 Planning

Canning

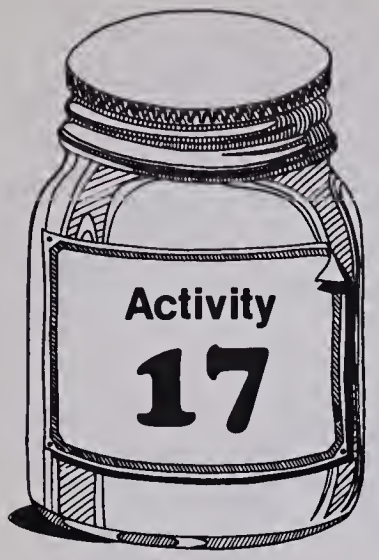
Activity 17 Page 66

We can thank Napoleon for canned foods. You'll learn a bit of history in this excursion. You'll also learn one way to can fruits.

Recipes and More Recipes

Activity 18 Page 72

Pickles, pancakes, and yogurt. (Ugh! Not all together of course.) Each recipe in this excursion features microorganisms or a way to protect foods from them. Cook, eat, and enjoy!

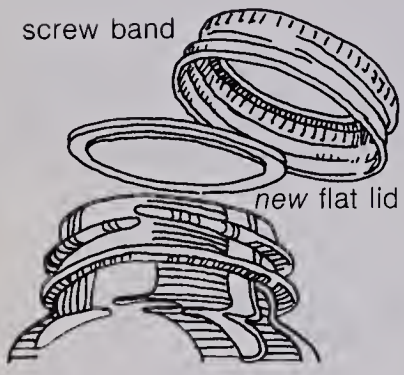


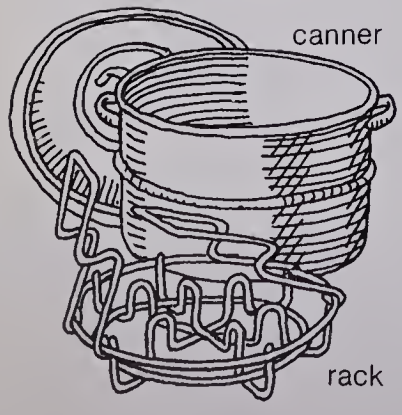
Canning

Over one hundred years ago, Napoleon offered a fantastic amount of money for a new way to preserve food. The French soldiers, fighting far from home, lacked a healthy diet. A method was needed for supplying the armies with a variety of foods, especially fruits and vegetables.

Nicholas Appert, an inventor and chef, worked hard for two years and perfected a method. He won Napoleon's prize and became instantly wealthy. Waterloo got Napoleon, but Appert got his cash and began a new food industry. Appert's method was canning.

Here is a recipe for canning peaches, apples, or pears. This activity may also be done at home. Before you begin, read through the entire recipe. You will need these items:

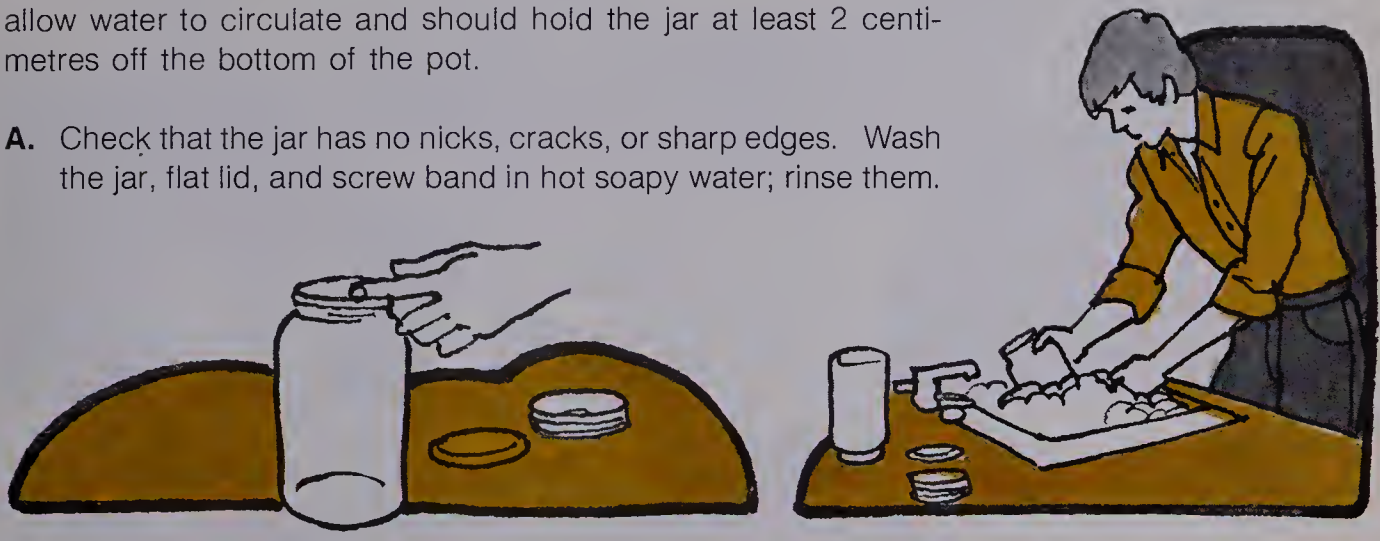




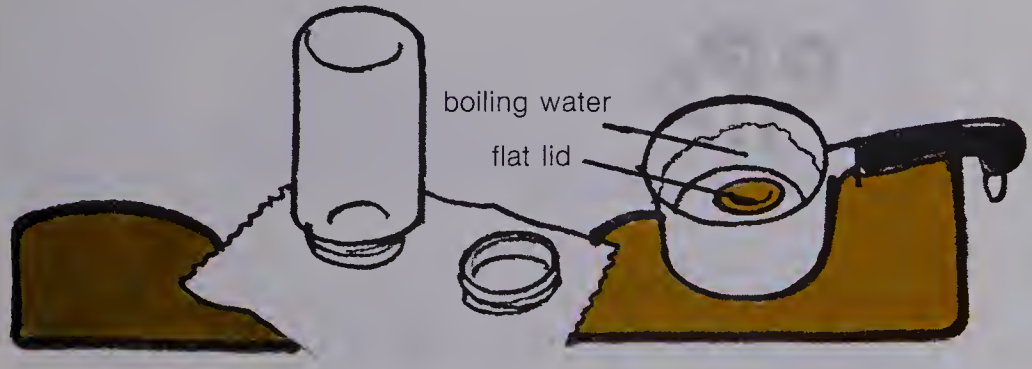
canning jar, 1-quart
2-piece lid for jar, including *new* flat lid and screw band
pan or pie plate
measuring cups and spoons
2 cups sugar
saucepan with cover
stove or hot plate
3 pounds peaches (or pears), firm and without bruises
wire basket or cheesecloth
saucepan of water
bowl, large enough to hold all fruit
kitchen knife
1 tablespoon lemon juice
table knife
canner with rack, or similar setup
watch or other timer
tongs, for lifting jar from water bath

If you don't have a canner, you can make one. Use a large pot with a cover. Your pot should be deep enough to cover the quart jar with water by at least 2.5 to 5 centimetres. If your pot is too small for a quart jar, use 2 pint jars. Place a cake rack or rack made of wooden strips on the bottom of the pot. The rack should allow water to circulate and should hold the jar at least 2 centimetres off the bottom of the pot.

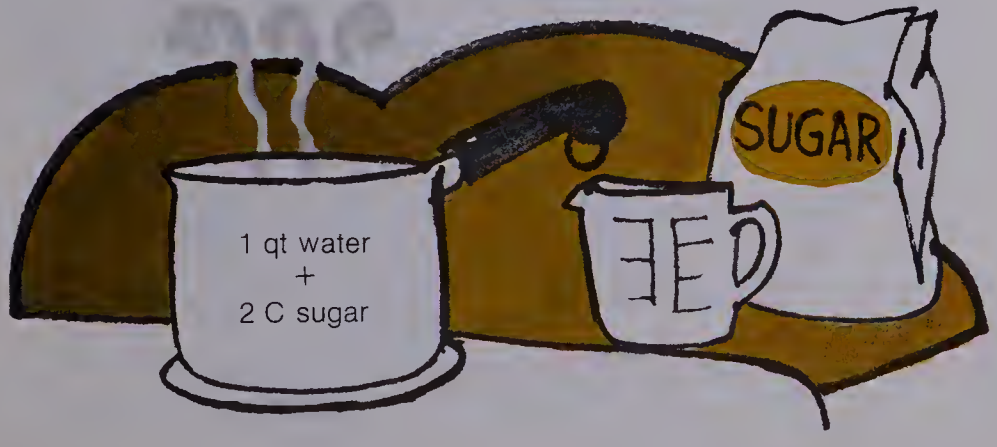
A. Check that the jar has no nicks, cracks, or sharp edges. Wash the jar, flat lid, and screw band in hot soapy water; rinse them.



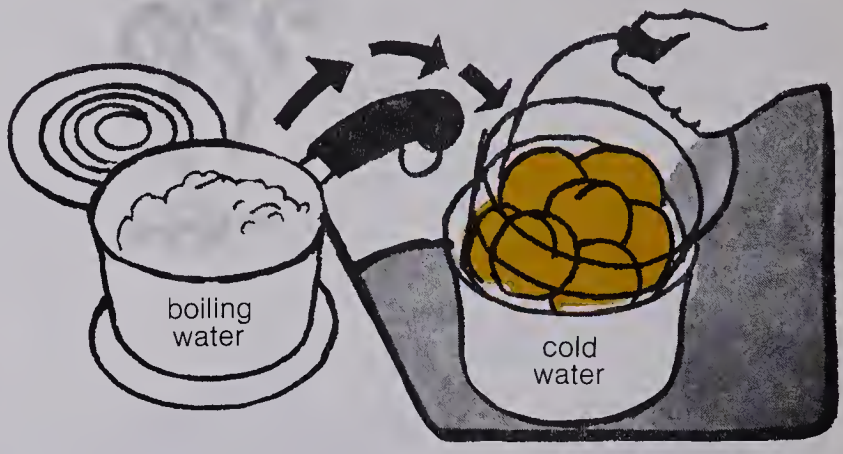
B. Turn the jar upside down on a paper towel or cloth. Place the flat lid in a pan or pie plate and cover it with boiling water. Leave the lid in water until you are ready to use it.



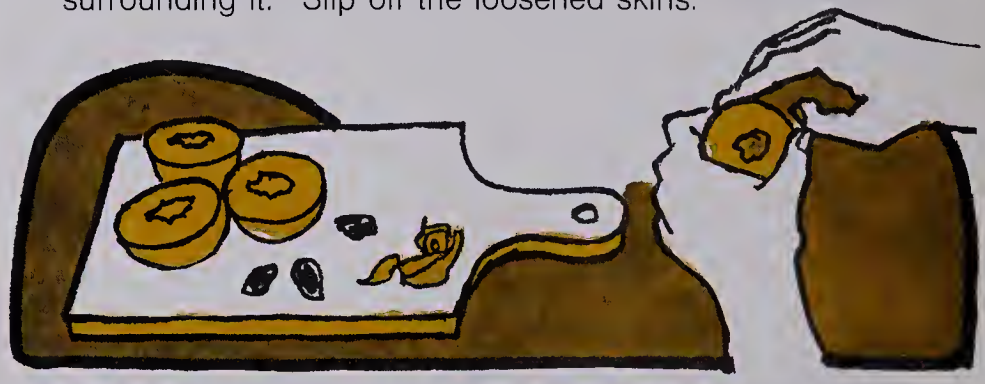
C. Combine 1 quart water and 2 cups sugar in a saucepan. Simmer the mixture to dissolve the sugar. Cover the saucepan to keep the mixture warm as you prepare the peaches.



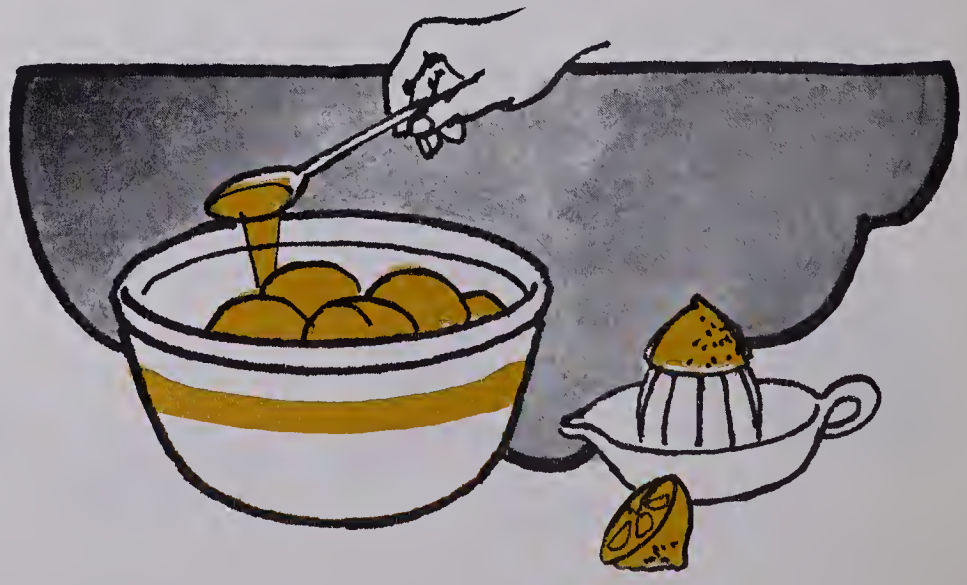
D. Wash the peaches in cold water. Put them in a wire basket or cheesecloth. To loosen their skins, dip them into boiling water for 30 seconds, then into cold water.



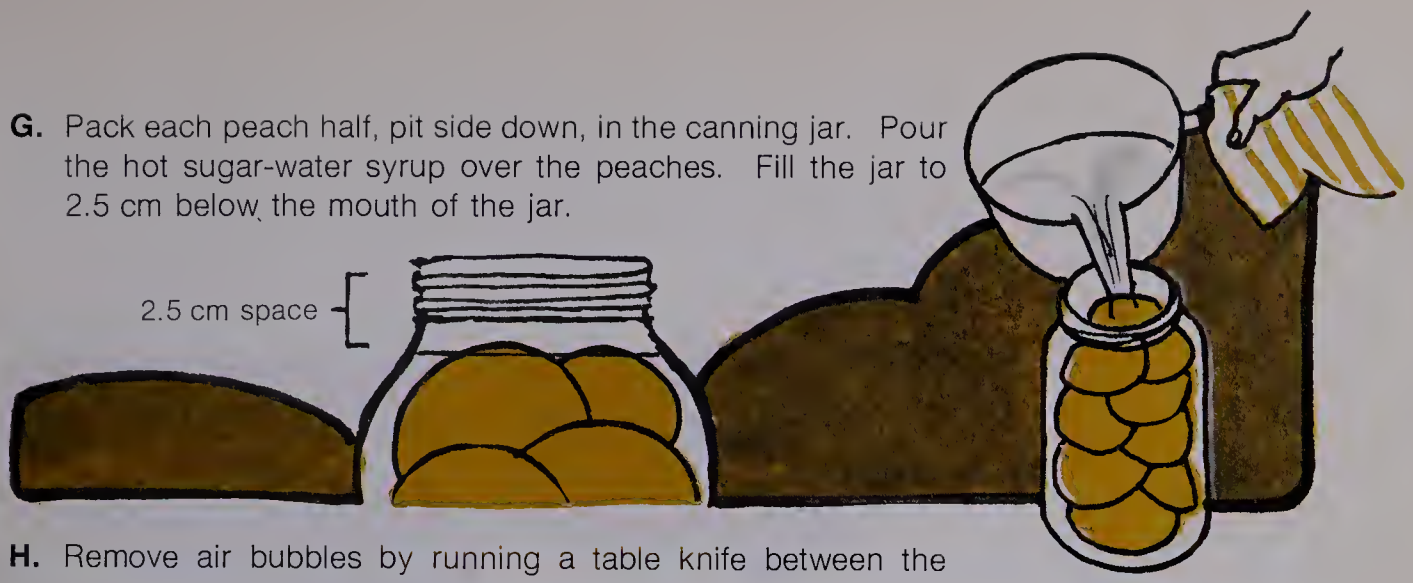
E. Cut each peach in half; remove the pit and the red fibers surrounding it. Slip off the loosened skins.



F. Place the peach halves in a bowl. Cover them with water and add 1 tablespoon lemon juice. Leave the peaches in the liquid for a minute or two. The lemon juice keeps the fruit from becoming brown.



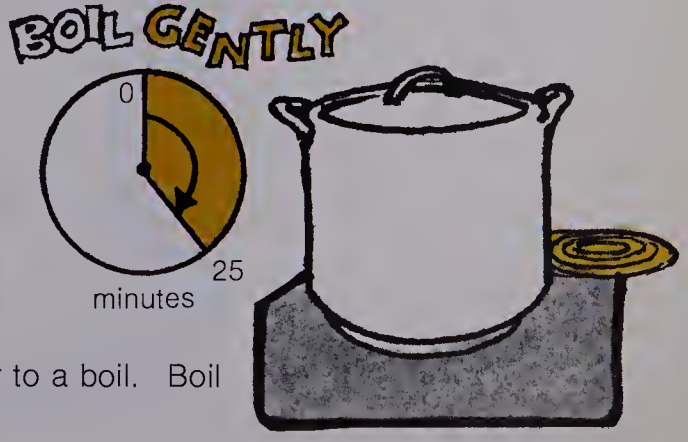
G. Pack each peach half, pit side down, in the canning jar. Pour the hot sugar-water syrup over the peaches. Fill the jar to 2.5 cm below the mouth of the jar.



H. Remove air bubbles by running a table knife between the peaches and the jar. If necessary, add more hot syrup to fill the jar to within 2.5 cm of the mouth. Wipe the top and threads of the jar with a clean damp paper towel or cloth.

I. Put the flat lid on the jar. The rubber-like sealing material lies on the mouth of the jar. The lid is held in place by the metal screw band. Screw the band on tightly.

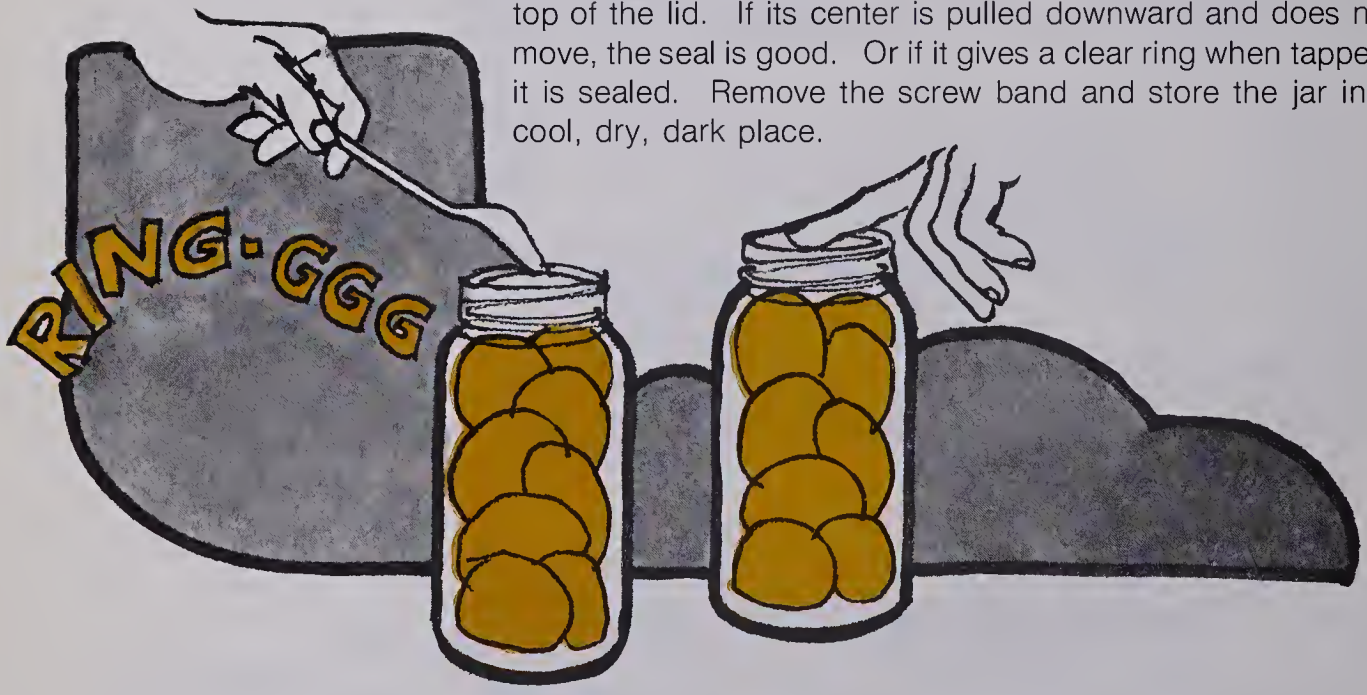
J. Place the jar on the rack in the canner. Add hot, but not boiling water. The level of the water should be kept 2.5 to 5 centimetres above the lid of the jar.



K. Put the cover on the canner. Bring the water to a boil. Boil gently and steadily for 25 minutes.

L. Use tongs to remove the jar from the water bath. The lid seals as it cools. Do not tighten the lid; if you do, you may break the seal. Set the jar on wood, a paper pad, or wire rack to cool slowly for 12 hours or more. Keep the jar away from any drafts.

M. After the jar is completely cooled, check the seal. Press the top of the lid. If its center is pulled downward and does not move, the seal is good. Or if it gives a clear ring when tapped, it is sealed. Remove the screw band and store the jar in a cool, dry, dark place.



★ **17-1. Which of these causes of spoilage were eliminated by the canning method that you used?**

a. bacterial spores? **c. molds?**
b. bacteria? **d. yeasts?**

If you have trouble answering Question 17-1, refer to Activity 9. The high temperatures used in canning destroy still another cause of food spoilage: the chemicals in food called *enzymes*.

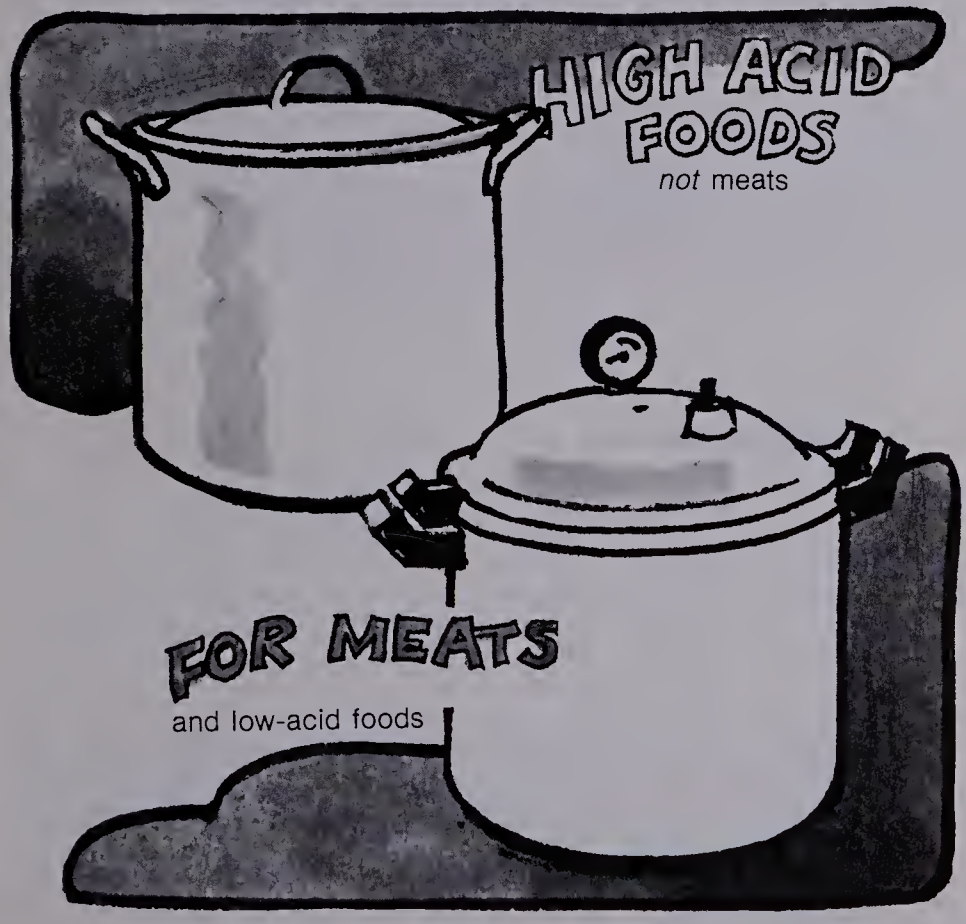
★ **17-2. How does the sugar in the syrup preserve the fruit?**

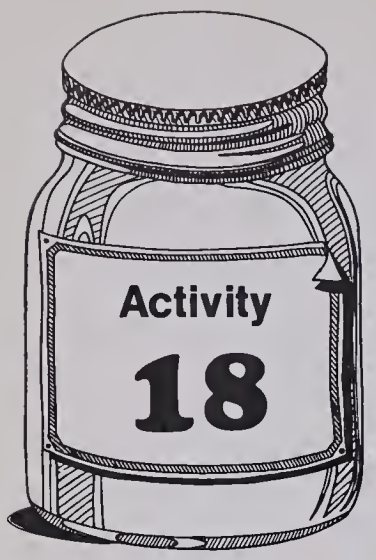
★ **17-3. How does boiling the jar of fruit preserve the fruit?**

CAUTION

You must use a pressure cooker to can foods low in acid.

Water boiling in a canner is hot enough to kill bacteria, molds, and yeasts, but *not* certain bacterial spores. Water boiling in a pressure cooker *is* hot enough to kill the spores. If you are canning something acidic such as fruit, you don't have to worry about surviving bacterial spores. Bacteria don't grow well under acidic conditions. In canning foods low in acid, such as meat, fish, poultry, and vegetables, you must use a pressure cooker in order to kill the bacterial spores.

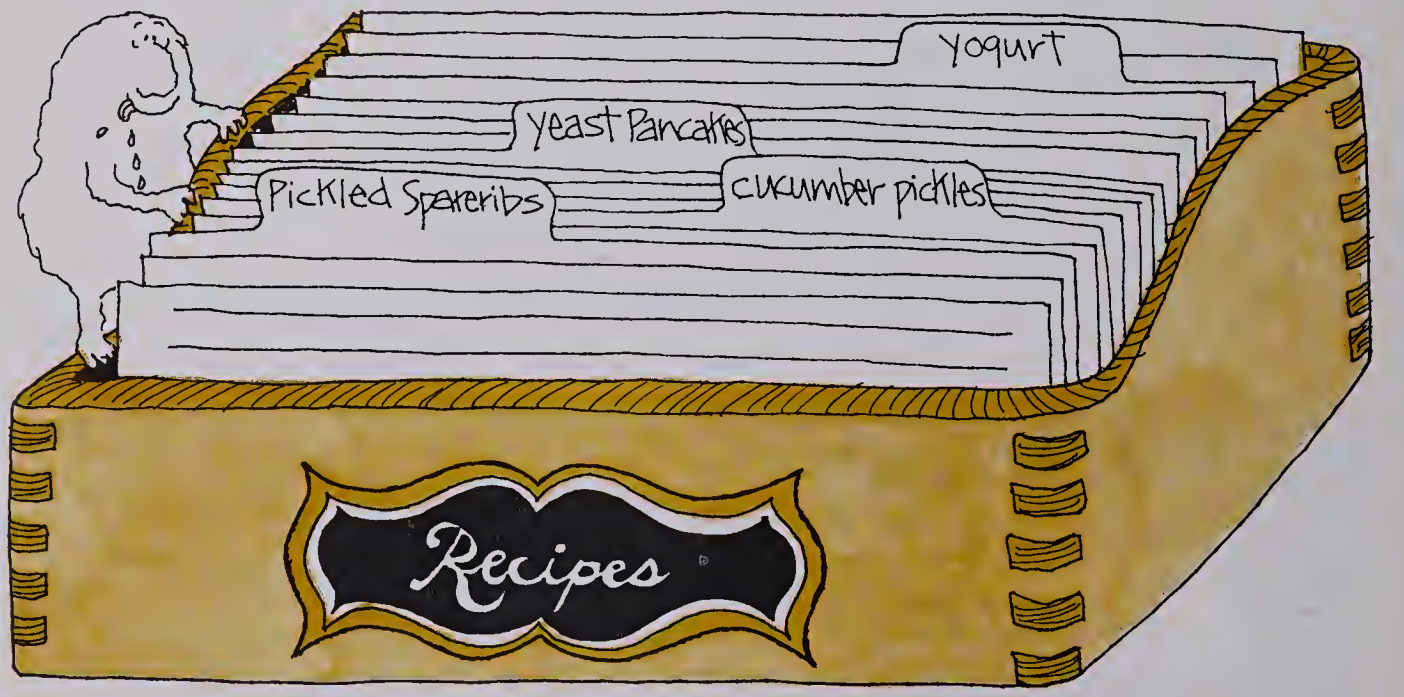




Recipes and More Recipes

This excursion contains several easy-to-follow recipes that involve the action of microorganisms. You may choose to do one, two, or all. You may need to supply your own materials. You may do these recipes at home in your kitchen or in the science laboratory.

Before beginning a recipe, read it through. Then collect the equipment and ingredients that you need.



CAUTION

Eat the pickled cucumbers and spareribs within a week.

The recipes for the cucumbers and spareribs will preserve these foods for only a short time. If you wish to preserve the pickles for a long time, you must use a boiling water-bath method and special canning jars and lids. You can get directions from a home economics teacher.

Long-Brine Cucumber Pickles

● Wash thoroughly in cold water 3 pounds pickling cucumbers, small, whole, firm, and unbruised.

● Sterilize a 2-quart bowl of glass, enamel, stainless steel, or pottery by boiling in water for 20-minutes.
(Don't use a metal bowl that may react with acid or salt.)

● Place the cucumbers in the bowl. If you wish, add $\frac{1}{8}$ teaspoon of one or more of these spices:
dried dill
celery seed
mustard seed
garlic powder.

● Combine and pour over the cucumbers
$\frac{1}{3}$ cup pickling salt
1 quart water
$\frac{1}{2}$ cup white vinegar, 5% to 6% acidity.

● Just inside the bowl, place a heavy dinner plate or similar item to hold the cucumbers under the brine.

● Hold the plate down by putting a weight on it such as a glass jar filled with water. The brine should just cover the plate.

● Place the container of pickles in a warm place (about 30°C) for 2 or 3 weeks. Everyday remove the scum that forms on top of the brine.

The brine draws moisture and sugars from the cucumbers. Bacteria in the brine ferment the sugars to acetic acid, or vinegar. As the brine becomes more acidic, it prevents the growth of microorganisms that cause the spoilage of cucumbers.

When the waiting period is over, drain the pickles and feast away!

★ **18-1. What is the effect of the salt in the pickle brine on the food spoilers in the brine?**

★ **18-2. What is the purpose of the vinegar in the recipe?**

Pickled Spareribs

- Rinse in cold water
  4 pounds spareribs.

- Place them in a saucepan of stainless steel or enamel. (Don't use a metal one that may react with acid.)

- Cover the spareribs with
  3 cups water
  1 cup white vinegar, 5% to 6% acidity.

- Simmer about 2 hours until tender. Do not allow the meat to fall from the bones.

- Remove the spareribs from the broth and place them in a bowl of glass, enamel, stainless steel, or pottery. (Don't use a metal one that may react with salt or acid.)

- Skim all the fat from the broth. Then add to the broth
  ½ cup vinegar
  ½ teaspoon pickling spices
  2 teaspoons salt
  ¼ teaspoon pepper.

- If needed, add more vinegar to make a total of 3 cups of broth. Pour the broth over the spareribs.

- Lightly cover the bowl of spareribs with a loosely fitting dinner plate or similar item.

CAUTION

Never seal pickled meats.

Sealing pickled meats can result in food poisoning. The vinegar solution draws proteins from the meat and calcium from the bones. The protein and calcium may lessen the strength of the vinegar. In the sealed container, there is little oxygen and low-acid levels; there the bacteria causing botulism can thrive.

Do not cover the spareribs tightly. Refrigerate them for 3 to 5 days, then serve.

★ **18-3. Why is botulism poisoning so dangerous?** (Activity 8 in the core will help you answer.)

Yogurt

- In a saucepan on a range burner, place
  2 cups whole milk, skim milk, or half-and-half.

- Heat at low temperature (to about 83°C) until bubbles form around the edge of the pan. Cool the milk (to about 42°C) until it is comfortable to your finger.

- Now work quickly. Rinse, with hot water, a 2-cup container of earthenware or other heat-resistant material.

- In the container, put
  1 heaping tablespoon of plain, unflavored commercial or homemade yogurt.

- Add a small amount of the cooled milk and stir quickly until smooth. Add the rest of the milk and stir.

- Set the container into a deep pan of warm water. The water level should come to the rim of the container.

- Cover the pan and put it in a warm place (about 38° to 50°C). If you have a gas range, the pan can be placed over the pilot light or in a warming oven. If your range is electric, it cannot be used; then place the pan over a heater.

- Check the thickness of the yogurt after 3 hours. Refrigerate it immediately after it becomes thick. The yogurt can be stored at least 5 days in the refrigerator.

- Serve the yogurt with fresh fruit, sugar and vanilla, brown sugar and cinnamon, or a topping of your own invention.

★ **18-4. Why does yogurt taste tangy?** (Hint: Bacteria naturally in the milk ferment the sugars in the milk. What are the sugars changed to?)

Pancakes

Made with Yeast

- In a saucepan on a range burner, heat $1\frac{1}{4}$ cups milk.

- As you let the milk cool to a lukewarm temperature, sprinkle 1 package active dry yeast into $\frac{1}{4}$ cup very warm water (about 40° to 44°C).

- Let the yeast-water mixture stand for a few minutes, then stir it to dissolve the yeast. In a large mixing bowl, combine the lukewarm milk and the yeast-water mixture.

- Add
  1 teaspoon salt
  1 teaspoon sugar
  2 tablespoons melted butter or margarine
  2 cups all-purpose flour
  1 well-beaten egg.

- Beat this batter with a spoon for 2 minutes. Set the batter in a warm place to rise until doubled in size.

- When the batter is ready, heat a griddle or large frying pan.

- Drop some water onto the griddle. If it sizzles and bounces, the griddle is ready. Grease the griddle with a small amount of shortening.

- Place spoonfuls of batter on the griddle. When the top of a pancake is covered with unbroken bubbles, turn it over. The second side cooks twice as fast as the first. Serve the pancakes warm.

★ **18-5. What purpose does yeast serve in the pancake recipe?**

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